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MEMOIRS OF THE GEOLOGICAL SURVEY,
SCOTLAND.

THE ECONOMIC GEOLOGY
OF
THE CENTRAL COALFIELD OF SCOTLAND.

AREA IV.

PAISLEY, BARRHEAD, RENFREW,
AND THE WESTERN SUBURBS OF GLASGOW
NORTH AND SOUTH OF THE CLYDE.

PRESENTED BY HIS MAJESTY'S GOVERNMENT

BY

L. W. HINXMAN, B.A., F.R.S.E.; E. M. ANDERSON, M.A., B.Sc.;
AND R. G. CARRUTHERS, F.G.S.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.

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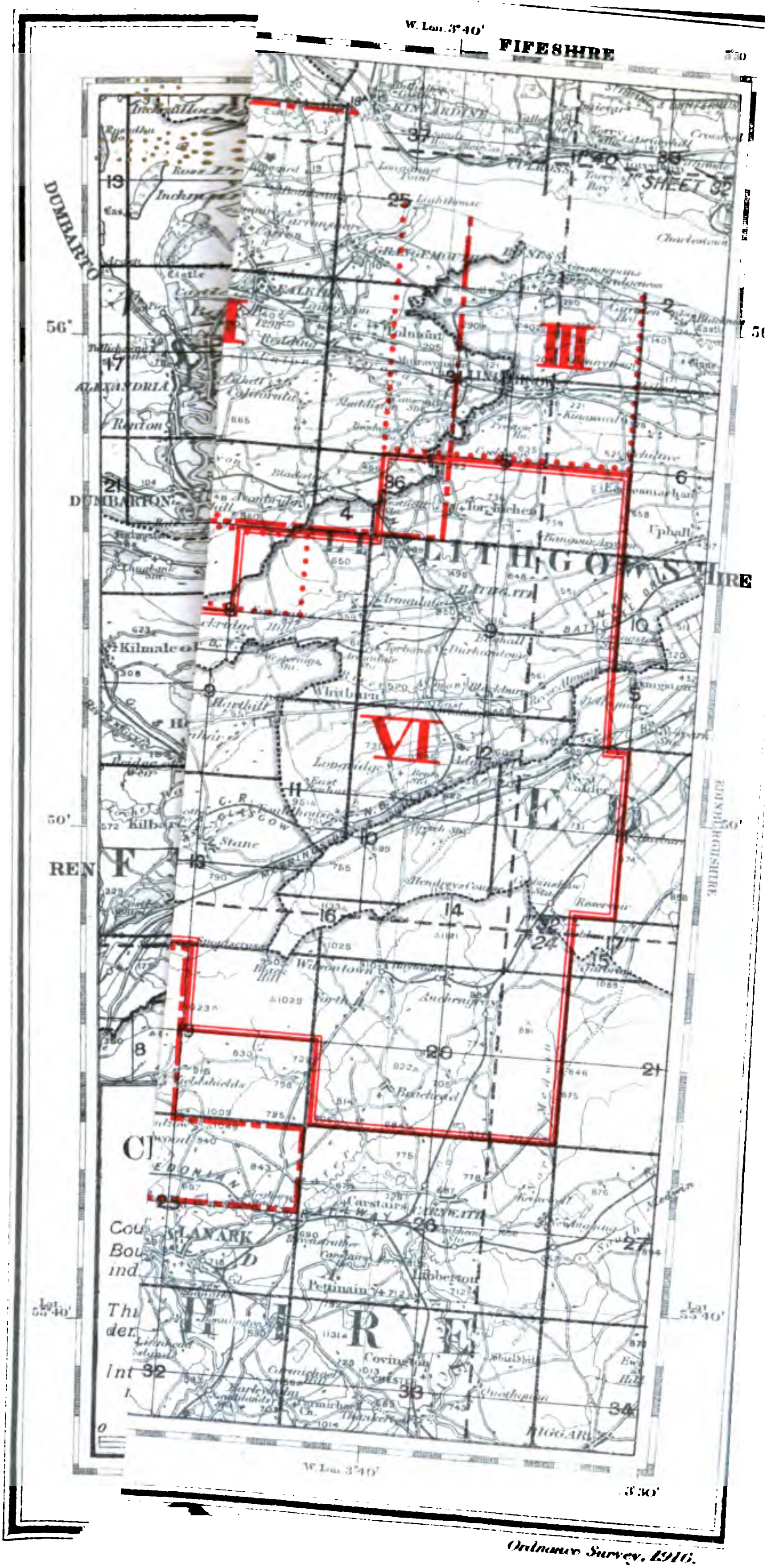

Ordnance Survey, 1916.

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PREFACE BY THE DIRECTOR.

THE district described in this Memoir forms the Area numbered IV. in the Index Map of the Central Coalfield of Scotland supplied as the Frontispiece. It lies on either side of the river Clyde in the counties of Renfrew, Lanark and Dumbarton, and is almost wholly included in Sheet 30 of the one-inch Ordnance Survey Map.

The ground was originally surveyed in 1868–72 by (Prof.) E. Hull, R. L. Jack and (Prof.) James Geikie, but no Memoir of Sheet 30 as a whole has yet been issued.

The revision, of which the results are embodied in the following pages, has been carried out in the Johnstone, Paisley and Barrhead district by Mr. R. G. Carruthers; in the Glasgow district, north of the Clyde, by Mr. Carruthers and Mr. Hinxman; and south of the Clyde between Govan and Thornliebank by Mr. E. M. Anderson.

A general description of the eastern part of Area IV. was given in the Memoir on *The Geology of the Glasgow District*, published in 1911. Since that time much fresh information has been gathered, especially with regard to the coals and ironstones of the Glasgow district; this work has been largely carried out by Mr. M. Macgregor. The Memoir has been edited by Mr. Hinxman. The thanks of the Survey are due to Colliery Proprietors and Managers, Mining Engineers and others, for valuable information freely supplied during the progress of the revision.

A. STRAHAN,
Director.

Geological Survey Office,
28 Jermyn Street, London, S.W. 1,
22*nd March* 1919.

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In Pocket at End of Volume.

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THE ECONOMIC GEOLOGY OF THE CENTRAL COALFIELD OF SCOTLAND.

AREA IV.

Area IV. falls mainly within one-inch Sheet 30 of the Geological Map of Scotland, but partly within one-inch Sheet 22. The complete list of six-inch Sheets (see Plate I.) is as follows :—

Renfrew, 7 N.E., S.E. ; 8 N.W., S.W., N.E., S.E. ; 9 N.W., S.W ; 11 N.E., S.E. ; 12 N.W., S.W., N.E.,* S.E.,* ; 13 N.W., S.W.,* S.E. ; 16 N.E. ; 17 N.W.
Lanark, 1 N.W., S.W.,* N.E., S.E.* ; 5 N.E., S.E. ; 6 N.W.,* S.W.* ; 10 N.W.,* S.W. ; 16 N.W.
Dumbarton, 23 S.W., N.E., S.E.* ; 24 N.W., S.W. ; 25 N.W., N.E.* ; 26 N.W. ;
Stirling, 27 S.W., S.E.* ; 32 N.W., N.E.*

Certain of these will not be issued as geological sheets, the information regarding the county in question being wholly included in the overlapping sheets of adjoining counties, as follows :—

Renfrew 9 N.W. and S.W. included in Dumbarton 25 N.E.*
Lanark 1 N.W. „ „ Stirling 32 N.E.*
Dumbarton 24 N.W. „ „ Stirling 32 N.W. and 27 S.W.
„ 24 S.W. „ „ „ 32 N.W., N.E.* and Lanark 1 S.W.
Dumbarton 25 N.W. „ „ Renfrew 8 N.W. and N.E.
„ 26 N.W. „ „ Lanark 1 S.W.*

In addition, those small portions of the following sheets which fall within Area IV. are included as follows.—

Renfrew 13 S.E. included in Lanark 10 N.W.*
Lanark 1 N.E. „ „ Stirling 32 N.E.*
„ 10 S.W. „ „ Renfrew 13 S.W.* and 17 N.W.

Revised editions of the sheets marked with an asterisk (*) are published.

CHAPTER I.

INTRODUCTION.

THIS Memoir forms one of a series published in description of the geology—mainly from the economic point of view—of the Central Coalfield of Scotland, which includes the whole of the Lanarkshire coal basin together with portions of the counties of Renfrew, Dumbarton, Stirling, Linlithgow and Edinburgh.

The frontispiece of this volume shows the division of the Central Coalfield into separate areas for purposes of description, each area having an individual Memoir.

The Index Map, Plate II., shows on a larger scale the region described in the following pages, with the included Six-inch Quarter Sheets and the surface area occupied by the chief geological formations.

The western half of the area under consideration, south of the Clyde, lies almost entirely within the county of Renfrew, and extends eastwards from Bishopton, Bridge of Weir and Howwood to Cathcart and the Clyde between Glasgow Bridge and Old Kilpatrick. On the north side of the river it includes the west-central and north-western parts of the City of Glasgow, and stretches northwards to Milngavie and the Kelvin valley above Balmore.

The Coal Measures entering into the ground described in this Memoir are very small in extent, and practically negligible from an economic point of view. The area, however, includes extensive mineral fields on both sides of the Clyde in which the coals and ironstones—both blackband and clayband—of the Carboniferous Limestone Series have been largely wrought in the past; and south of the river may be more extensively wrought in the future. The Calciferous Sandstone strata of the Paisley district contain the Ferguslie fireclays and the remarkable Quarrelton Thick Coal, of which a full description is now for the first time supplied. Further areas in which fields of coal, ironstone and limestone as yet untouched are likely to be found are also indicated.

For convenience of description the whole area has been divided into two main districts: (1) The Johnstone and Paisley District; (2) The Glasgow District, the latter being further subdivided into (*a*) area south of the Clyde; (*b*) area north of the Clyde.

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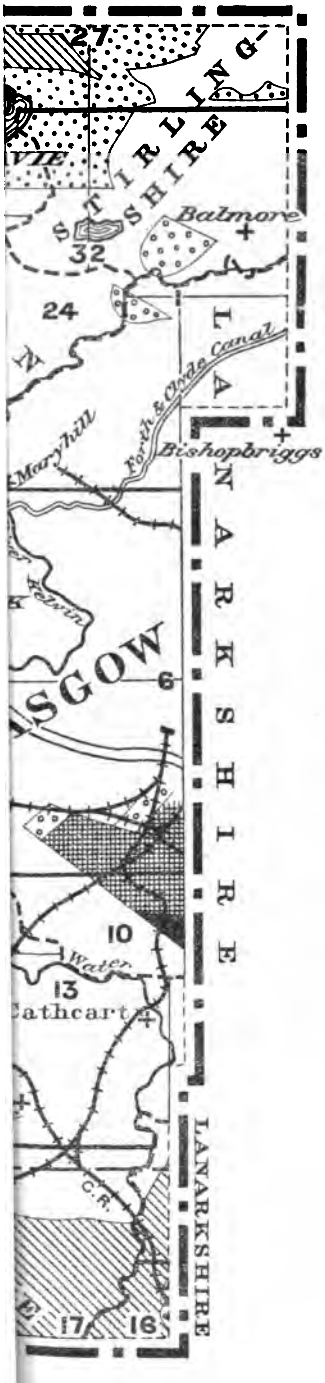

CHAPTER II.

JOHNSTONE AND PAISLEY DISTRICT.

Renfrew, 7 N.E., S.E.; 8 N.W., S.W., S.E., N.E.; 11 N.E., S.E.; 12 N.E.,* N.W., S.E.,* S.W.

THE Johnstone and Paisley district described in the following pages covers some 40 square miles, all within the county of Renfrew. Most of the ground is low-lying, falling imperceptibly in a north-east direction to the extensive flats along the river Clyde. To the south and west are stretches of bare upland, whose abrupt escarpment is particularly marked on the south side of Paisley.

All the contemporaneous igneous rocks in this area are of Carboniferous age. The upland fringe is composed of Calciferous Sandstone volcanic rocks, belonging to the system of Clyde Plateau lavas: on these rest the Upper Calciferous Sandstone and Carboniferous Limestone sediments, covering all the low ground and abounding in seams of limestone, coal and ironstone, and occasionally invaded by intrusive sheets of basic igneous rock. The whole area may be regarded as the western termination of the Central Coalfield of Scotland: in the past it has been the scene of much mining activity at present in abeyance, although the capacities of the district are by no means exhausted.

The sequence of the sedimentary rocks is incomplete; much of the basal measures is cut out by a prominent overlap on to the lavas below, resulting in an unconformity of variable amount, and occasionally leading to the entire exclusion of the Calciferous Sandstone rocks. Again, while there is a full development of the Lower Limestone Group, the Upper Group is barely represented by the Index Limestone and a few fathoms of overlying strata, found in a single locality in the small basin at Linclive, north-east of Johnstone,

The general succession, representing a maximum for the district. is shown graphically in Fig. 1.

There are good sections of the rocks of the Calciferous Sandstone Series and Lower Limestone Group to the south and west of Paisley and Johnstone, those of the limestones near Bridge of Weir and at Howwood being of particular importance; nothing, however, is seen of the Middle or Limestone Coal Group above, and our knowledge of the sequence in that group is entirely derived from boring and mining evidence.

The original survey of the ground was carried out about the year 1870, by Mr. R. L. Jack, whose work has required very little modification. Since that time not much had been added to our knowledge of the geology of the district until the year 1913, when an important

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* The description of the Carboniferous Limestone rocks in Renfrew, 12 N.E., S.E., will be found in the chapter dealing with the Glasgow area south of the Clyde.

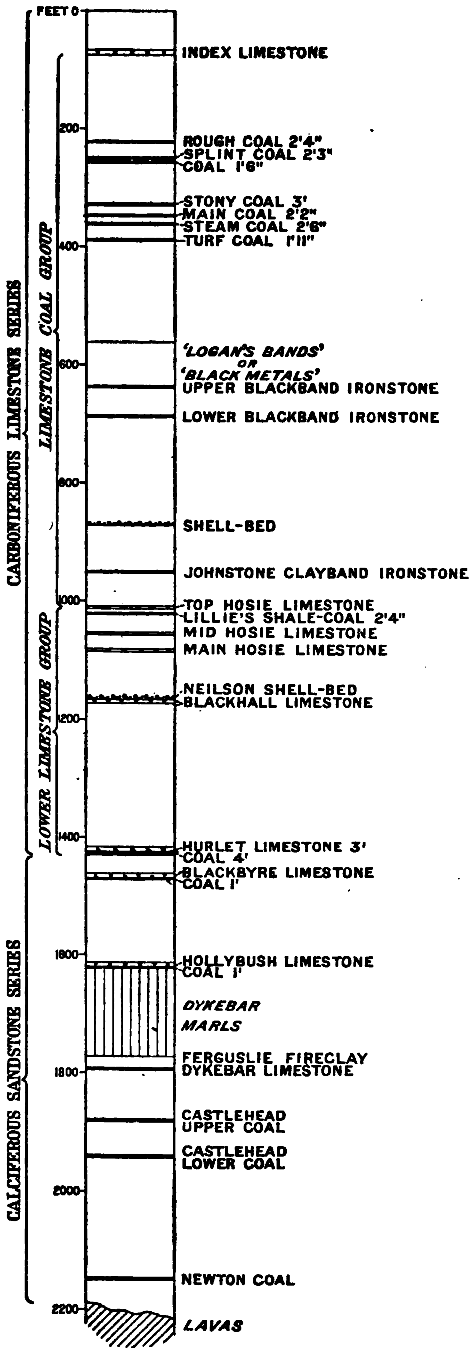

FIG. 1.—General Section of the Carboniferous Strata below the Index Limestone, in the Paisley and Johnstone district.

paper dealing with the Lower Limestone Group was published by Messrs. Macnair and Conacher.[*]

The later official revision, while largely confirming the work of Mr. Jack, has added much new information respecting the Calciferous strata, in which the sequence has been definitely established, that below the Hollybush Limestone being new: attention may also be drawn to the description of the Quarrelton Thick Coal, and of the curious line of disturbance known as the "Paisley Ruck."

Main Structural Features.—The general synclinal arrangement of the sediments is broken by several subsidiary folds, and by frequent faulting. Three great lines of dislocation cross the area: the first, the "Paisley Ruck,"[†] runs south-west from Renfrew past the north side of Paisley and beyond Johnstone towards Lochwinnoch. The displacements on either side may be, and often are, of slight amount, but within the zone of disturbance, which is 200 or 300 yds. in breadth, all the strata are crushed and broken in a very remarkable manner. For a short distance, near Linwood, the displacement amounts to 300 fms.; but this is purely local.

The Blythswood Fault, on the left bank of the Clyde, trends north-west, and has a southerly downthrow of 200 fms. at Renfrew, decreasing westwards to 100 fms. The third line of fracture, the Newton Fault, traverses the south side of Paisley; it is a normal east-and-west fault of 60 to 70 fms., with a downthrow to north, and can be traced right across the district.

The folds are relatively gentle, and their axes have no common orientation. There is an exceptionally well-defined syncline, with axis trending S.W., at Linclive on the west side of Paisley. Other synclinal folds at Howwood and at Limecraigs near Stanely, are situated on opposite sides of a pronounced anticlinal axis that crosses the south part of the district in a general west-by-south direction.

THE CALCIFEROUS SANDSTONE SEDIMENTS.

The general sequence in these strata has already been shown in Fig. 1; but for convenience of description a recapitulation is tabulated below.

GENERAL SECTION OF THE CALCIFEROUS SANDSTONE SEDIMENTS IN THE PAISLEY DISTRICT.

(See also Pl. VIII., Sections 2–5.)

	Fms.	Ft.	In.
BALDERNOCK OR "WHITE" LIMESTONE (in floor of Hurlet Seam) . . .	0	3	0
Strata	4	0	0
BLACKBYRE LIMESTONE	0	3	0
COAL	0	1	0
Strata	16	0	0
LADY ANN COAL	0	0	6
Strata	5	0	0
HOLLYBUSH LIMESTONE	1	0	0
COAL	0	1	0
Strata	5	0	0

---

[*] "The Stratigraphy of the Limestones lying immediately above the Calciferous Lavas in the Glasgow District," by Peter Macnair and H. R. J. Conacher, *Trans. Geol. Soc. Glasgow*, vol. xv. (Part 1), 1914, p. 37.

[†] For a fuller description of the Paisley Ruck, see pp. 45–7.

	Fms.	Ft.	In.
SANDHOLES COAL	0	2	0
Dykebar Marls	20	0	0
FERGUSLIE ("BROWN'S") FIRECLAY	1	0	0
Strata	3	0	0
DYKEBAR LIMESTONE	0	2	0
COAL—very foul	0	1	0
Strata	10	0	0
CASTLEHEAD UPPER COAL	0	3	0
Strata	10	0	0
CASTLEHEAD LOWER COAL	1	1	0
Strata	35	0	0
NEWTON COAL	0	3	0
Strata (up to)	80	0	0
Lavas			

It must not be supposed that the above sequence is fully developed all over the district: this is by no means the case, for the sediments overlap on to the lavas below in a most irregular manner. Their greatest known thickness is reached under the town of Paisley, where a deep boring for water, put down in 1889 at Messrs. Coats' Ferguslie Thread Works, passed through 80 fms. of sandstones, fakes, etc., beneath the Newton Coal position before reaching the lavas, into which it was further carried for 50 fms. This bore started 25 fms. above the Castlehead Upper Coal and struck the lavas at about 145 fms.: it is therefore probable that the total thickness of the Calciferous sediments hereabouts, from the Hurlet Coal downwards, measured about 180 fms. (1080 ft.).

Elsewhere, much less sediment was deposited; near Houston and Bridge of Weir the Castlehead Coals and lower strata are all missing, the lavas having been above water nearly up to the time of the formation of the Hollybush Limestone, while to the south of Johnstone they are found close beneath the Castlehead seams (the Quarrelton Coal). Under the centre of the Howwood syncline the volcanic rocks immediately underlie the Hurlet Coal, showing that at this point there was practically no accumulation of Calciferous sediment whatever. This is an extreme case of overlap, not paralleled in any other part of the Paisley or Glasgow districts: the section at Thorntonhall, near East Kilbride, is the nearest locality where similar phenomena are found.*

The Limecraigs Section—(Plate VIII., Section 5).—There are many small exposures of Upper Calciferous Sandstone strata in the district, but only in the neighbourhood of Limecraigs—2½ miles S.S.W. of Paisley Cross—is anything like a continuous sequence met with. The stream on the east side of the quarries, with its tributary the Wardhouse Burn, affords sections of 45 fms. of strata ranging from the Castlehead Lower Coal very nearly up to the Hollybush Limestone. On the west side of the quarries another stream section shows the higher beds from the Hollybush Limestone to within a few feet of the Hurlet Coal. The whole sequence amounts to 80 fms., and the section is invaluable as affording confirmation of an order of succession established largely by boring evidence obtained elsewhere in the district.

The lowest beds known lie beneath the Newton Coal, and little can be said about them. In the bore at Messrs. Coats' works, referred to above, these strata were recorded as a monotonous sequence of sandstones and fakes, with occasional partings of blaes. A 17-in. coal was met with 52 fms. below the Newton Coal position, and two limestones, 19 and 4 in. in thickness, are recorded in the journal. These were probably not true limestones, but hard limy marls or kingle: a similar instance was met with in sinking the Newton Pit, where a 30-in. 'limestone' recorded 3 fms. below the Newton Coal, proved, on examination of a sample, to be a hard limy marl spotted with sphærosiderite (Pl. VIII., Section 3.) It may be mentioned that a bore put down from the workings in this coal reached the lavas at 7 fms.; a much less distance than in the other bores to the north-east. In a bore for water at Messrs. Clark's Anchor Thread Mills, Paisley, nearly 70 fms. of fakes, sandstone and fireclay were passed through below the Newton Coal position, and a very similar succession was met with in another boring at M'Farlane's Dye Works.

---

* "The Economic Geology of the Central Coalfield of Scotland, Area VIII." (*Mem. Geol. Surv.*), 1917, p. 13.

It is somewhat remarkable that in spite of the thickness of sandstone passed through and the fact that many of these sandstones crop out on higher ground to the south, these bores have nevertheless failed to yield any appreciable quantity of water.

It is possible that the sections in the Caledonian Railway cutting on the west side of Stanely Reservoir are in strata below the Newton Coal. The cutting shows a 10-ft. bed of soft freestone with a conglomeratic base, resting with a slight unconformity upon fireclay and flaggy sandstone. The freestone reappears in several old quarries south-west of the railway. Other outcrops of sandstone to the east of Glenfield Scouring Works may also lie beneath the Newton Coal; they are well seen in Rabbitneuk quarries, and also in a smaller opening 400 yds. to the west of Brownside farm-house, where the sandstone shows irregular bedding and pebbly bands, with many flattened Calamite stems lying at all angles. At the top of this quarry fine glacial cross-striæ are seen, those pointing north-and-south being apparently older than, and partially obliterated by, those which trend east-by-south.

The *Newton Coal* is the lowest seam ever worked in the west of Scotland: it lies about 105 fms. beneath the Hurlet Seam. The pit (Newton Coal Pit) was closed down in 1914 after being in operation for 10 years; it was situated on the west side of the "Chain Road," nearly half a mile S.S.W. of Ferguslie Fireclay Works, where the coal was used. The shaft reached the coal at 30 fms., but was sunk to 33 fms. 5 ft. in order to work a fireclay 2 fms. beneath the coal. On the north side of the pit the Newton Fault, with a downthrow to the north of 55 fms., was encountered and proved in the workings, a mine being driven through it to reach another bed of fireclay on the north side. The Newton Seam was here from 3 to 6 ft. in thickness—a bituminous coal, but very quick-burning and tender. There was a rib in the centre, and locally the seam thinned down to only 15 in.

An average section of the working was—

	Ft.	In.
Fireclay, not worked	3	6
FOUL COAL	1	0
FREE COAL	1	6
Fake ribs	0	6
COAL	2	3
Fireclay pavement		

The workings were practically flat, and there must be at least a square mile of ground to the south and west where this coal is untouched: over this unexploited area the inclination of the beds is very gentle and towards the west.

The Newton Coal has been proved at several points on the south side of Paisley, mostly in borings for water, in which the thickness of the seam may have been somewhat underestimated. In Messrs. Coats' bore it was recorded as 8 in. of coal in two leaves separated by 27 in. of black blaes, and at the Anchor Thread Works it was only 6 in. in thickness.

The Survey possesses an old report on bores near the "Chain Road," from which it would appear that a 2½-ft. coal was at one time wrought on a small scale from a pit 8 or 9 fms. in depth situated "near Lounsdale Works." From the pavement of this seam a bore was put down which got 15 in. of foul coal at 11½ fms. Beyond these facts nothing can be ascertained with regard to these old workings; possibly the seam wrought in this shallow pit was the Newton Coal, which should be near the surface in this direction.

The two *Castlehead Coals* (see Pl. VIII., Sections 3 and 5) were at one time of some importance and were wrought from a very early period. The Paisley Town Authorities worked these coals at Gallowgreen—*i.e.*, close to Paisley West Cross—from 1650 to 1652, an interesting record of early municipal enterprise.* Less than a century ago they were raised at the Old Castlehead Pit, on the east side of Paisley West Station, and subsidences into the old wastes have occurred at West Street. There was also, before the year 1870, a shallow pit at the side of the Glen Burn, about 500 yds. N.N.W. of Glenfield Works, a mile south of the town. Impure ironstone was wrought here together with the coal (the lower seam), but the venture proved a failure.

The Castlehead Lower Coal is the thickest coal seam in the Calciferous Sandstone rocks, with the exception, of course, of the abnormal Quarrelton Coal. It is, however, of very inferior quality.

The only known exposure is that seen along the Wardhouse Burn, S.E. of Limecraigs.

The complete section is given below:

SECTION IN WARDHOUSE BURN.

(See also Pl. VIII., Section 5.)

		Ft.	In.
	Sandy marl and fireclay	1	0
	FOUL COAL and fireclay partings	1	0
	Grey sandy fireclay	3	0
	Yellowish-white kingle rib	0	8
	Sandy fireclay	1	6
	Kingle rib	1	0
	Grey sandy fireclay	3	0
LOWER CASTLEHEAD COAL with fireclay partings, 8 ft. 3 in.	FOUL COAL and fireclay partings	3	0
	Fireclay	0	1
	FOUL COAL	0	4
	Grey fireclay	0	3
	FOUL COAL and fireclay partings	0	7
	Fireclay, dark grey	1	0
	FOUL COAL and fireclay partings	3	0
	Hard yellow marl with rootlets		

---

* "The History of Paisley," by Provost R. Brown, Paisley, 1886. Vol. I., pp. 241, 279.

The lower 8 ft. of the above sequence extends some way up the south bank of the burn: the rest is seen in the stream itself.

The whole seam, when exposed with a little digging, looks quite imposing, but a closer inspection reveals the presence of innumerable thin partings of fireclay which render it practically useless at the present time: in years past, before better coals were known, it could no doubt be used to some extent, as is shown by the working of the Paisley pits.

The *Castlehead Upper Coal* crops out further downstream, just before the footbridge is reached; it is 6 ft. in thickness, with the same interlamination of fireclay as in the Lower seam.

Both coals have been proved in many borings to the north and east, where they appear to lie in a shallow syncline, which marks the easterly extension of the Limecraigs trough. The average thickness of the Upper seam in these bores is 4 ft.; of the Lower, 5 ft.: both coals are recorded as 'foul.'

One of the most interesting of these trials was No. 2 bore, Thornley Blair, on the west side of Thornley House. It was put down on the outcrop of the Upper Castlehead Coal, and found the Lower seam (5 ft. 4 in.) at 11½ fms., the Newton Coal ('coaly blaes, 3 ft. 8 in.') at 37 fms., and finally reached the lavas about 80 fms. from the surface.

North of the Limecraigs syncline is a belt of barren ground, extending to the Newton Fault and containing strata which lie entirely below the Castlehead Coals. Five bores put down in this area proved nothing of value, the Newton Coal being thin. To the east a 50-fm. fault, trending nearly due north through Potterhill, brings in the Castlehead Coals again to the east. A deep bore by the stream at the foot of Stony Brae, Burnfoot, started on the outcrop of the Upper Castlehead seam, passed through the Lower Coal ('5 ft. 8 in. foul coal, blaes and fireclay') at 8 fms., the Newton Coal ('foul coal, 1 ft.') at 37 fms., and entered the lavas at 116 fms., the intervening strata consisting of sandstone, fakes, fireclay and blaes, with red and brown marls at the bottom.

Near Elderslie the Castlehead Upper Coal can be seen in the old sandstone quarries at Lex Wood. It rests upon the freestone—which has been proved between the two seams over most of the Paisley district—and is covered by a sill of dolerite, better exposed in the quarries to the south. At the east end of the Lex quarry the coal is 4 ft. 6 in. thick and rests upon flaggy sandstone, but at the west end it does not measure more than 3 ft. and has a bed of fireclay, 3½ ft. thick, below. The coal is in poor condition, being badly burnt by the dolerite.

On the north side of the Newton Fault the Castlehead Coals have been proved in two bores close to the old Hollybush Limestone workings in the trough at Brediland. The best section was given by No. 2 bore, east of the quarries: this proved the Upper seam, 3 ft. 9 in. thick, at 57 fms., and the Lower, 7 ft. 3 in., at 65 fms.: both are described as 'very bad coal.' Until quite recently, the Castlehead Lower Coal could be examined in the workings at the Caledonia Fireclay Pit, Paisley. It lay at a depth of 62 fms. between two beds of fireclay: the latter were wrought, but the coal, though 8 to 10 ft. in thickness, was useless even in the kilns: it looked bright and soft, but the presence of countless thin intercalations of fireclay rendered it of no value.

The remarkable development of these coals further to the west at Quarrelton and its vicinity receives special treatment in the sequel (pp. 19–28).

The Dykebar Limestone, one of the most interesting of the recently-established horizons in the Calciferous Sandstone Series of this area, was first recognised in the Hawkhead Burn on the north side of the Caledonian Railway Station at Dykebar, 1½ miles south-east of Paisley Cross; it was but briefly referred to in "The Geology of the Glasgow District," as its true position in the sequence was then unknown.*

Another outcrop, where the bed is typically developed, occurs in the bed of the same stream 400 yds. S.E. of Dykebar Station. It is a dark, impure limestone, distinctly irony, with a deep, ochreous weathering, and is full of Producti and a variety of small, marine brachiopods and lamellibranchs: a black, coaly fireclay lies underneath.

An excellent section of the Dykebar Limestone is also exposed in the Wardhouse Burn, east of Limecraigs, a few yards below the fork in the stream: the details of this section are as follows:—

Section in the Wardhouse Burn, East of Limecraigs.

(See also Pl. VIII., Section 5.)

		Ft.	In.
	Sandstone flags	30	0
	Coaly fireclay	0	1
Dykebar Limestone	Pale bluish-grey mudstone and blaes with plant stems and occasional *Pecten*-like lamellibranchs; *Spirifer* and *Productus*.	1 to 3	0
	Hard, grey, irony Limestone, impure, with deep ochreous weathering: *Productus*, *Spirifer*, small gasteropods, *Lithodomus* sp., *Bellerophon*, Entomostraca, *Discina*, etc.† In irregular beds 0 to 1 ft. 6 in. In all up to 2½ ft.	2	6
	Pale bluish-grey mudstone, some *Productus* and *Spirifer* at top.	0	6
	Coaly blaes, papery	0	6
	Grey fireclay with coaly layers	8	3
	Massive, hard, marly fireclay in lumpy beds, full of sphærosiderite		

This section is the best in the district, and the only one where the relationship of the Dykebar Limestone to the surrounding strata can be studied. One other exposure of this horizon is known; it occurs on the right bank of the Black Cart, a few yards above the ruins of Hagg Mill, Johnstone.

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* *Mem. Geol. Surv.*, 1911, p. 17. It is there stated that the limestone contains *Lithostrotion*, but this specimen was obtained from a loose block in the stream, which may be a drift-carried boulder from the Hollybush Limestone.

† Also *Leiopteria divisa* (M'Coy). This rare lamellibranch, which is a characteristic fossil of the Dykebar position at all the known localities, is elsewhere found at much lower horizons:—in the Cementstone Series of Liddesdale and at the base of the Oil-shale Group near Edinburgh. One specimen in the Survey collection comes from the lowest Abden Limestone of Kinghorn.

The section is:—

	Ft.	In.
Sandy grey blaes	2	0
Grey blaes with cement nodules and a few fossils	3	0
Grey blaes crowded with small brachiopods, lamellibranchs, etc.	0	6
Grey LIMESTONE with brachiopods, etc.	0	9
Roof of old coal working		

At this locality it is the characteristic assemblage of fossils which identifies the position, for the surrounding strata are poorly exposed. The coal beneath the limestone has evidently been worked here on a small scale, for a few hundred yards up the river: this seems to be the only place where it has been found good enough to work as an independent seam, though it locally forms a component part of the Quarrelton Thick Coal, to be described later.

Higher up the bank at Hagg Mill an outcrop of dolerite forms a prominent escarpment upstream, where traces of the underlying fossiliferous blaes are also visible. This sill is an extension of the intrusion which appears round Quarrelton and covers much of the ground at the east end of Johnstone. Immediately north of Hagg Mill it is brought down to the river bed by a fault trending west-by-north, probably a branch of the great line of dislocation which throws down the Lower Limestone Measures further to the north, within the town.

The Dykebar Limestone and Coal have been proved in many bores in this district. The clearest section is perhaps that given by No. 1 bore Brediland. This bore started on the outcrop of the Hollybush Limestone (9 ft. 10 in.) and, passing through 20 fms. of the red Dykebar Marls, reached the Dykebar Limestone at a distance of 35 fms. below the Hollybush: the coal beneath was only a foot thick. This bore is important, not only as showing the relations of the Hollybush and Dykebar Limestones, but also those of the lower strata, since it further proved the position of the Castlehead Coals, as already described.

In the duplicate section supplied by No. 2 bore, a little further east, the Dykebar position is given as 'soft limestone,' 2 ft. 9 in. thick in two bands, with 2½ ft. of coaly blaes and 10 in. of coal below.

In the shaft section at the Caledonia Fireclay Works, Paisley, the limestone measured 3 ft. 7 in. and the coal 9 in.

A valuable feature of the Dykebar Limestone is its service as a reliable index-mark for the position of the *Ferguslie Fireclay,* which lies 3 to 4 fms. higher in the sequence and was for long raised at Messrs. Brown's works at Ferguslie, Paisley (see Plate VIII., Section 3). The original holdings of this well-known clay are now practically exhausted, and a good "index" to its position should be of use in exploring new ground towards Barrhead, where the seam will be found.

The Ferguslie Clay in the original workings was mined under the Brediland syncline up to the Newton Fault. The shaft, closed down about the year 1905, lay between the works and the railway, and was 15 fms. in depth; the section was as follows:—

		Fms.	Ft.	In.
	Boulder-clay, etc.	2	0	0
	Red marls (Dykebar Marls)	8	3	0
	Sandstone	1	4	0
FERGUSLIE CLAY MAIN SEAM	FIRECLAY	0	3	9
	COAL	0	0	6
	FIRECLAY	0	3	6
	Sandstone			

A "Lower Clay" underlay the sandstone beneath the Main Seam, but was only slightly worked. The Main Seam was of excellent quality and suitable for the production of the best sanitary ware.

The Ferguslie Clay was also worked about 1¼ miles to the N.E. in the Caledonia Pit, as the "Mid Seam," at a depth of 40 fms. It was there irregular in thickness, and by no means of such good quality as at Ferguslie—a variation common to most fireclays. The leaf of coal in the centre of the clay seam was here replaced by one or two ft. of 'stone,' the average section being:—

		Ft.
	Sandstone	
"MID SEAM" (Ferguslie Main)	FIRECLAY	5
	Stone	1 to 2½
	FIRECLAY (bally)	5
	Sandstone	

The most promising unproved area of the Ferguslie Fireclay is probably the broad stretch of Calciferous Sandstone between Dykebar and Barrhead; the position of the clay will certainly be met with here, and at no great depth, but of its quality nothing is yet known: the fireclay seen by the stream in the plantation north-east of Dykebar Hill must represent the Ferguslie seam or one close to it.

The *Dykebar Marls* are generally 20 to 25 fms. in thickness, and form a conspicuous member of the Calciferous Sandstone sequence. They consist, in the main, of impalpable red marl, crumbling rapidly when exposed to weathering. Greenish bands also occur as well as frequent layers of 'kingle' sandstone and hard 'calmy' marl, slightly calcareous: these have been erroneously recorded as 'limestone' in the Caledonia Shaft section and in some of the bores in the district. The best natural section is found along the Wardhouse Burn, east of the quarry in the Hollybush Limestone at Limecraigs. Other sections are exposed in the streams east of Dykebar Hill and along the Black Cart below Cartside Mill, Millikenpark. The marls are also partially visible in the railway cutting east of Paisley Canal Station, where a bore for water at Messrs. Bell's Dye Works proved 15 fms. of these rocks. These marls may at first sight be taken for fine volcanic tuff, but closer inspection reveals the presence of minute flakes of muscovite, indicating their detrital origin: they are, no doubt, a wash from a deeply-weathered surface of the Clyde Plateau lavas. The horizon is widespread and is mainly developed south-east and west of Paisley.

The *Sandholes Coal* immediately overlies the Marls and, as a workable subject, is of purely local occurrence: it is in several leaves with partings of fireclay. The only working known was in operation before 1870 from a 17-fm. pit on the east side of Sandholes farm, a mile N.W. of Johnstone, where it was erroneously known as the "Lady Ann" Coal, a higher seam once wrought between Hurlet and

Barrhead. A bore close to the Sandholes pit proved 9 ft. 4 in. of coaly strata, with much dirt, the section showing:—

	Fms.	Ft.	In.
Whinstone			
Fireclay, faky	1	5	6
Daugh and coaly partings	0	1	0
FOUL COAL	0	1	6
Fireclay	0	0	4
FOUL COAL	0	1	0
Fireclay	0	4	3
VERY FOUL COAL	0	1	3
Fireclay pavement			

The workings were on quite a small scale and were limited by a downthrow fault south-west of the pit. In the Caledonia Shaft, Paisley, the Sandholes position is recorded as 15 in. of coaly blaes on 7 in. of coal, with 6 ft. 9 in. of fireclay below, followed by 1 ft. of coal. In a bore on the south side of West Fulton, 1¼ miles N.N.W. of Johnstone, the Sandholes Coal was proved at 41½ fms., there being 5 ft. 3 in. of coal and fireclay. In another trial made in 1865, by the railway 700 yds. south of East Fulton, the Sandholes Coal was got at 75 fms.: in this bore there was 3 ft. of coal and fireclay followed by 3 ft. 10 in. of blaes, fireclay and ironstone, with 3 ft. 8 in. of coal and fireclay below. This section is of great interest since it starts above the Johnstone Clayband Ironstone, and proves the whole sequence of the Lower Limestone Group together with much of the Calciferous Sandstone Series below.

The Hollybush Limestone and Coal is a prominent horizon all over this district, and until recent years was the lowest whose position in the Calciferous Sandstone sediments of the west of Scotland had been definitely fixed. Good exposures of this highly fossiliferous seam occur in the eastern part of the area at Hollybush, N.N.W. of Barrhead, and at the reservoir within the grounds of Hawkhead House, N.W. of Hurlet village. The section at the latter locality has already been described in "The Geology of the Glasgow District":* it is visible at the south end of the reservoir, when the water is low, and reveals about 4 ft. of limestone, full of brachiopods and corals, resting on a 14-in. coal.

The Hollybush Limestone is persistent south of the Clyde, having been found also in bores at Hillington, Deanfield and Shieldhall, between Paisley and Govan.

In the Paisley district several other exposures are known: one of the clearest is in the south bank of the cutting on the Canal Railway at Saucel Hill, Paisley, where the limestone dips gently to S.S.E. The details of this section are given below:—

	Ft.	In.
Hard limy blaes, full of crushed brachiopods including *Productus giganteus* and *P. costatus*	1	0 (seen)
Hard light-grey crinoidal LIMESTONE, ochreous weathering; small brachiopods, etc., with a band of *Lithostrotion irregulare*, *L. junceum* and *Syringopora* in the centre. At the bottom the limestone contains cement nodules with Entomostraca	3	0

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* *Mem. Geol. Surv.*, 1911, p. 18. A list of fossils from this locality is given on p. 83 of the same Memoir.

	Ft.	In.
Light-grey limy blaes, crushed brachiopods, etc.	0	6
Hard grey LIMESTONE : *Lithostrotion martini*, seen	1	0
Soft light-grey papery blaes	0	6
Dark grey alum shale : plant debris and small flattened *Lingula* common	0	6
Parting of blaes full of pyrites dust	0	0¼
Hard black slate with streaks of COAL	0	6
Bright COAL	0	6 (seen)

Other important exposures of this horizon are found at Limecraigs, south of Paisley (Pl. VIII., Section 5). On the east side of the syncline little can now be seen in the old quarry, but besides a fragmentary view of the chief limestone band with its corals, one can note that the under part of the limestone is greenish-black in colour with white shells scattered through it. This character is of value, for when the limestone is next seen in the stream west of the quarries, its identification is at first sight difficult; the main post has been quarried out leaving only the underlying greenish-black bed—unlike any development of the Hollybush Limestone in the ground to the north and north-east.

This limestone was worked many years ago to the south of Brownside, east of Glenfield, and the Survey has a good collection of fossils from the locality. Amongst these the true, coarse-ribbed *Productus giganteus* is prominent, together with *P. latissimus.* The latter species is generally characteristic of the Upper Limestone Group, and its occurrence at so low a horizon is of interest. Most of the old workings at Brownside are now overgrown, and only the upper part of the Limestone can be seen.

On the west side of Paisley the Hollybush Limestone outcrop appears on the north bank of the Gryfe Water, 100 yds. below Ladeside Cottage, near Houstonhead, Bridge of Weir. Six feet of limy blaes is here exposed, full of crushed Producti and with a 3-ft. *Lithostrotion* band in the centre: this usually rests directly on a 3-in. coal, though at one point a ½-in. rib of blackband ironstone intervenes between the blaes and the coal. Beneath the coal lies 1 ft. 6 in. of fireclay, succeeded by 7 in. of coal upon marly fireclay.

The section is complicated by a fault throwing down to the north which follows the bed of the river, but in places leaves it sufficiently to show the Limestone at the edge of the stream, thrown up by the fault against sandstone and marl. A dolerite dyke, seen along the north side of the fault, has burnt the lower (7-in.) seam of coal.

A short distance down stream, on the right bank near Coalbog, another outcrop of limestone is seen: this is apparently a higher bed and is described later (p. 17).

A fragmentary exposure of the Hollybush seam occurs in the railway cutting east of Bridge of Weir Station. This section was recorded by Mr. R. L. Jack in the original survey, but the limestone was not identified, and its recognition is due to Mr. H. R. J. Conacher. The cutting is much overgrown, and the rocks are disturbed by the proximity of the powerful fault running from Johnstone to Bridge of Weir.

The Limestone appears again near Houston village in disused quarries east of the Manse. The freestone once worked here rests upon 7½ ft. of limy blaes with *Productus latissimus* and *Lithostrotion*, with a 7-in. coal below. Part of the section reappears at the bend in the River Gryfe, 450 yds. to the south-east, the strata being brought up on a gentle anticlinal fold, cut off by a fault on the south side.

The old quarries at Garnieland, N.W. of Renfrew, were in this limestone: this is shown by bores in the vicinity, one of which, at Wrightlands, Inchinnan, proved 10 ft. of limestone upon 4½ in. of coal: 2½ fms. further down the Sandholes Coal position was got; the section of the seam showing:—

	Ft.	In.
Clean Coal	0	8
Coaly fireclay	1	4
Fireclay and rib	4	5
Soft foul Coal	1	4

An 'ingaun e'e' showing 2 ft. of limestone is still open south of Garnieland; the workings were probably in the underlying coal. The Hollybush Limestone position is well developed in this part of the district; it was also met with at 50 fms. at New Mains, and got, 6 ft. 3 in. thick, in another bore by the railway, 1 mile N.W. of Houston Station.

To return to the area south of Paisley—nothing is now seen *in situ* in the disused quarries at Elderslie and Brediland, although at the latter locality loose blocks of the limestone, crowded with its characteristic fossils, can still be found. The underlying coal was at one time mined on the north side of the quarry, but would not be over 18 in. thick.

The last section of the Hollybush Limestone to be described is met with in the Swinetrees Burn, 400 yds. S.E. of Meikle Corseford. Only the upper part of the bed is seen, the band appearing on the crest of a low anticline cut off on the north-west by a fault with a downthrow in that direction, seen further down the stream. The limestone or limy shale is full of the usual Producti and *Lithostrotion junceum*.

A bore for water at the Manse near the cross-roads in Howwood village started on the crop of this limestone, which was 5 ft. 8 in. in thickness with a 10-in. coal below. The Dykebar Marls were proved beneath the coal; they are well exposed in the stream south-west of the village.

Until the pit was closed down in 1914, the Hollybush Limestone could be seen at the Caledonia Fireclay Works, Paisley, where it made an excellent roof to the coal and fireclay workings. This was the highest seam in the pit, and lay within a few fms. of the surface. The section read:—

		Ft.	In.
	Limestone	4	1
	Blaes parting	0	6
	Limestone	2	0
Working	Hard coaly slate	1	6
	Soft Coal	1	0
	Fireclay	5	4
	Sandstone		

The limestone roof is a dark crinoidal stone with the usual Producti: the coal, though wrought with the fireclay, proved of little value. At the time of working the seam was thought to represent the Hurlet Limestone and Coal, but apart from the character of the beds, its identification with the Hollybush is fully confirmed by the shaft section, which proved the Dykebar Marls and succeeding strata, all in their proper order.

The *Lady Ann Coal* is of little account in this district, and where known in the west and north-west is but a few inches in thickness. It appears to have been worked in two old pits between Blackbyre and Townhead, where it was 18 in. thick. The coal was reached, but not wrought, in the Victoria Pits, Nitshill. The seam lies generally about 10 fms. above the Hollybush Limestone position, but approaches it more closely in the western stream sections at Limecraigs. At its outcrop by the Gryfe Water west of Craigends the coal is much interleaved with fireclay: there is a tradition that it was wrought here, but at the present time the seam would hardly be regarded as a practicable subject. It has been found in bores at Hillington, east of Paisley—where a thin rib of blackband ironstone was present—and at Deanside, near Renfrew, and continues across the Clyde into the Craigmaddie district.

The Blackbyre Limestone—a limestone of thoroughly marine type,—is well known in bores to the west and south-west of Paisley, but is rarely visible at the surface. Over the Glasgow district generally this seam is thin-bedded and flaggy, and crowded with small brachiopods, but contains practically no corals.

The best natural exposures, although by no means the most typical, occur at Limecraigs, south of Paisley. The total thickness here must be some 24 ft.—about twice the average figure for this district. All but the lowest part of this limestone can be seen in the quarry on the east side of the Limecraigs syncline (Pl. VIII., Section 5): the section here is interesting on account of some evidence of unconformity at the top of the limestone.

The details are as follows:—

		Ft.	In.
	Red and grey marl	4	0
	Irregular band of brecciated cream-coloured cement in a marly matrix	0 to 2	6
	Red and yellow marl	3	6
	Sandstone flags resting directly on the underlying limestone—the line of contact is undulating, but there are no pebbles at the base of the sandstone, and the unconformity is probably small	8	0
BLACKBYRE LIMESTONE	Crinoidal LIMESTONE; often with reddish weathering	5	0
	Poor, flaggy LIMESTONE with crinoids and Producti	8	0
	Solid grey LIMESTONE, crinoidal . at least	5	0

On the west side of the basin the limestone reappears in the Gleniffer Burn, just inside the plantation south of the Filter Beds. In this section the lower beds are the best seen, the main post having been quarried out; while the overlying marls are only partially exposed. The section is:—

	Ft.	In.
Solid LIMESTONE (quarried out)		
Grey flaggy LIMESTONE with partings of limy blaes; both full of crinoid and brachiopod debris	14	0
Pale blue mudstone with *Modiola lata* .	2	0
" " (harder) . .	0	6
Hard, light-grey, irony rib	0	5
Hard coaly slate	2	0
Slaty COAL, poor	0	10
Coaly fireclay	0	4
Light sandy fireclay		

The coal and overlying black slate recall the Hollybush Limestone section in the Saucel Hill railway cutting at Paisley,* but the *Modiola lata* mudstone above is distinctive. This latter feature is repeated in the type district at Blackbyre, near Barrhead, and in the Caledonian Railway cutting near Blackhall.

There is a section near Bridge of Weir which may or may not represent the Blackbyre Limestone. The exposure occurs on the right bank of the River Gryfe, just above the ford at Coalbog, and is of interest from the fossil contents of some blaes which intervene between a coal and a marine limestone, and thus represent a transitional phase frequently characterised by rare or peculiar forms. The details are as follows:—

		Ft.	In.
BLACKBYRE LIMESTONE	Dark limy blaes with limestone nodules, both crowded with small crushed Producti, Athyrids, crinoid debris, etc., and towards the base scattered fragments of *Lithostrotion junceum*	4	0
	Lilac-coloured blaes, occasional brachiopods .	0	4
	Daugh	0	0½
	Dark, slaty blaes with *Actinopteria fluctuosa*, *Lingula*, Rhynchonellids, a small five-ribbed *Productus*, Goniatites and, in the lowest inch of the bed, *Posidonomya becheri* . .	0	4
	Pyritous "parrot" and blackband ironstone with a very finely ribbed *Productus*, *Lingula* and *Pinna* (the last two well preserved with traces of the original colour bands) in the upper half-inch, shading down through a "fish-bed" into parroty blaes with plants .	0	2½
	Bright, laminated COAL	0	5
	Yellowish-grey fireclay . at least	3	0

(See also Plate VIII., Section 4.)

The strata described above do not appear to lie more than 10 fms. beneath the Hurlet Limestone, which crops out at the bend in the stream below. This fact, together with the abundance of brachiopod debris, seems to refer them to the Blackbyre position. At the same time *Lithostrotion junceum*, a coral unknown elsewhere from the Blackbyre Limestone, though common in the Hollybush, is undoubtedly present—as first pointed out by Mr. H. R. J. Conacher in this section; which nevertheless differs greatly from the Hollybush Limestone exposed higher up on the left bank (see p. 14), crowded with *Lithostrotion* and showing no trace of the *Posidonomya becheri* slate band. Mr. Conacher has noticed a second coal rib beneath the fireclay; this is a point in favour of identification of the bed with the Hollybush, but the weight of evidence seems, on the whole, to point to a correlation with the Blackbyre Limestone.

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* See p. 14.

There are many bores (South Barr, East and West Fulton, Fulwood, Dargavel, etc.), in which the Blackbyre Limestone position has been proved, but of its character at these localities nothing is known. Probably it is similar to what is seen in the Caledonian Railway cutting east of Blackhall, south-east of Paisley, where 2 ft. of flaggy *Productus* limestone lies between 1½ ft. of dirty coal below, and 6 in. of dark calmy limestone of Pendleside type above. At this locality a 4-in. rib of light-grey blaes separates the coal and the limestone—its upper part full of *Myalina* aff. *flemingi* and nests of *Actinopteria fluctuosa*, as at Blackbyre itself.

In the year 1909 some shallow bores were put down along the White Cart, north of Sneddon Bridge in Paisley. One of these, at Carlile Quay, struck 'hard limestone rock' beneath 24 ft. of surface clay: this is probably the Blackbyre Limestone, which was proved 50 years ago, a few feet from the surface, on the opposite side of the river. Two other bores at the Adelphi and Cartvale Works went down to the Hollybush Limestone at 21 fms.

The Baldernock or White Limestone lies immediately beneath the Hurlet Coal. Although in the Campsie district, and around Hurlet, it is a white or cream-coloured nodular limestone with rootlets and entomostraca, and for this reason was formerly regarded as a freshwater deposit, the exposures near Paisley referred to below show it to be thoroughly marine in character. As regards the entomostraca (*Carbonia fabulina*) of the Campsie area, Mr. Neilson * was the first to point out that they differ from those found in the shales below the Blackhall Limestone (*Leperditia* sp.) which have yielded in addition only plant and fish remains. Near Bridge of Weir it is visible at low water in the bed of the Gryfe, on the right bank at the sharp bend below Coalbog, where it contains a few Producti, with green ashy marl filling the spaces between the nodules. A similar outcrop can be seen in the stream 300 yds. south-east of Meikle Corseford, near Howwood, where a small fault throws up the limestone against the Hurlet Coal. An identification with the Blackbyre position has been suggested for this exposure,† but the nodular character of the limestone and the accompanying green marls are distinctive of the Baldernock Limestone in this region, and have never been met with at the Blackbyre horizon. The position at Limecraigs is obscured by debris from the old quarries: the nodular cement that here overlies the Blackbyre Limestone can hardly represent the Baldernock Seam since it is quite unfossiliferous and is overlain by a good deal of red marl, whereas the Baldernock Limestone lies immediately beneath the fireclay forming the floor of the Hurlet Coal.

The position is recorded as " thin-bedded limestone with 'fireclay' partings" in numerous bores to the west and north-west of Paisley (East and West Fulton, South Barr, Inchinnan, Fulwood, Netherfield, Dargavel, New Mains, etc.), where the bed averages 10 ft. in thickness.

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* "Notes on the Geological Survey Memoir," *Trans. Geol. Soc. Glasgow*, vol. xiv. (Part 3), 1913, p. 335.

† See paper by Messrs. Macnair and Conacher, "The Stratigraphy of the Limestones lying immediately above the Calciferous Lavas in the Glasgow District," *Trans. Geol. Soc. Glasgow*, vol. xv. (Part 1), 1914, p. 40. Convincing evidence of the true position of this limestone was supplied in 1913 by a diamond bore at Meikle Corseford, where an identical bed, 11 ft. thick, with *Productus* and *Syringopora* was met with, 11 ft. below the Hurlet Coal.

THE QUARRELTON COAL.

It has long been known that around the hamlet of Quarrelton, immediately south of Johnstone, there is a very remarkable mineral seam known as the "Quarrelton Thick Coal." Although this is certainly the thickest single accumulation of coaly matter in Britain, and as such is well known to mining engineers, it seems to have been strangely overlooked by geologists. A special description of this phenomenon is therefore given here, dealing, among other matters, with the mode of origin and stratigraphical position of this coal, questions which have not hitherto received attention.

The facts already known may first be outlined. The outcrop (Fig. 2, Plate IV.) swings round an anticline in the grounds of Johnstone Castle, and is repeated on the south by a 30-ft. upthrow fault trending south-east. To the north it is cut off by the curious shatter-belt known as the "Paisley Ruck"; on the north side of this line of disturbance the seam is again met with, but at a somewhat greater depth. A thick intrusive sheet of dolerite or 'whin' overlies the coal, and supplies much of the local road-metal. The presence of the igneous rock seems to have had little or no effect on the seam, in which ribs of 'free' and gas coal are common. In the centre of the field and over an area of perhaps a square mile, the coal forms practically a single seam 40 to 50 ft. thick, while over about 18 acres on the east side of Craigston it is "doubled" and reaches the astonishing thickness of 100 ft. Not all of this, however, is good coal:—there are occasional partings of blaes ("till" or "indurated clay" in the old terminology), as is shown in the following section, taken where the coal reaches its maximum thickness.

SECTIONS AT QUARRELTON.*

	Fms.	Ft.	In.
Greenstone (dolerite)	18	0	0
Sandstone and indurated clay alternating in thin bands	4	0	0
Fireclay with coarse ironstone	2	0	0
COAL	1	4	0
Indurated clay	0	1	0
COAL	1	4	0
Indurated clay	0	2	3
COAL	1	3	0
Indurated clay	0	1	0
COAL	4	3	0
Indurated clay	0	1	0
COAL	1	4	0
Indurated clay	0	2	3
COAL	1	3	0
Indurated clay	0	1	0
COAL	2	5	0

Total thickness of coal, with clay partings, 100 ft. 6 in.

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[*] Drawn up by Robert Bald, and published in the article "Mine" in the Edinburgh Encyclopædia. This section is quoted in the description of the Parish of Paisley,—*New Statistical Account of Scotland*, vol. vii., 1845, Renfrewshire, p. 151, with the remark—"we have tested its accuracy." See also the old *Statistical Account*, vol. vii., 1793, p. 80.

The later description (1845) referred to in the footnote, speaks of "this vast body of coal" as consisting of ten beds, the fourth bed in the section (4½ fms.) being commonly reckoned as three beds, and the lowest coal (2 fms. 5 ft.) as two beds. In other parts of the field, away from the "doubled" area, only 5 seams were recognised. In an old plan of Benston Pit these are given as:—

	Ft.	In.
Smiddyhead Coal	10	0
Ironhead Coal	8	0
Merryhead Coal	10	0
Minehead Coal	7	0
Free Craighead Coal . . .	7 to 10	0
Total	42 to 45 ft.	

For reasons to be presently discussed, it is probable that an exact correlation of the component seams of the Thick Coal is impossible owing to the abrupt lateral change in the beds.

An excellent set of sections and a plan of the centre of the field was drawn up in 1800 by Mr. Wm. Watson: these are reproduced in Plates IV. and V.* and give a good general idea of the lie of the strata; and, having been prepared at a time when mining operations were in progress and abundant pit sections available, are of particular value. The development of the Thick Coal as practically a single seam is a purely local phenomenon and is probably confined to not more than half a square mile of ground. When traced outwards from this area, wedges of sandstones and "till" are found to come in rapidly on all sides, until the coal is soon split up into four distinctly separate seams.

Three questions remain for discussion:—the geological position of the Thick Coal; its mode of origin; and the mining conditions and prospects of future development.

Geological Position.—The stratigraphical position of the Thick Coal has always been obscure: the earlier miners do not appear to have investigated the matter, which nevertheless is one not only of scientific interest but of vital importance in prospecting for new fields outside the limited area of the coal already known. The original Survey Map and Sheet of horizontal sections of the district, prepared by R. L. Jack about the year 1870, indicate the position of the seam at some indeterminate horizon in the upper Calciferous Sandstone sediments, the coal being shown on the map as dipping beneath the Hurlet Limestone in the Howwood syncline.

The recent revision work has confirmed this approximation, which is further supported by the association of the coal with thick sandstones and marls together with an important intrusive sheet of teschenitic dolerite—a type of intrusion characterised by wide lateral range and relatively slight transgression of the strata, and therefore almost as useful as a sedimentary rock for purposes of correlation. No such association is met with in the Lower Limestone or higher groups in the Paisley district, while common enough in the upper Calciferous sequence. Other facts—such as the occurrence of lavas a few fathoms below the bottom seam of the Thick Coal in Craigenfeoch Pits and in bores at Hallhill—point in the same direction. The original view that the coal lay somewhere within the upper

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* From a tracing of the originals in the possession of the Geological Survey.

Calciferous sediments may thus be accepted as established: it remains to determine a more exact position for the seam.

At the time of the original survey only the highest part of the upper Calciferous sequence, down to the Hollybush Limestone, was known, and within that space the coals were so few and unimportant that the Quarrelton Thick Coal could hardly be among them,—apart from the fact that no limestone of the Hollybush type occurred in association with this coal or its component seams. The problem of its true position accordingly remained unsolved. It can now, however, be sought for in the lower strata beneath the Hollybush Limestone, where the determination of the sequence has been one of the most interesting features of the recent revision.

The generalised vertical section (No. 1, Plate III.) shows that in these lower beds there are four principal coal positions; the highest of these is found in the floor of the Dykebar Limestone, followed by the Upper and Lower Castlehead Coals, and, finally, by the Newton Coal. All these seams have a wide distribution over the Paisley district, and the upper three generally present beds of coal and coaly fireclay 6 to 10 ft. in thickness. With but slight lateral change it is not impossible that they might pass into coals of better quality and greater thickness, while a simultaneous attenuation of the intervening sediments would result in the accumulation of coaly matter of quite abnormal thickness. This, it may be surmised, is what has here taken place.

On the east side of the Quarrelton field, the Castlehead sequence can last be definitely recognised on the S.E. side of Elderslie, where the shaft sections and bores in the Newton and Brediland field (cf. Plate VIII., Section 3) have provided *data* for the construction of Section 1, Plate III. The "whin float" resting on the Upper Castlehead Coal may be noted; it is strongly developed in the Newton Quarries and can be traced, in much the same position, eastwards to Paisley.

The next section (No. 2, Plate III.) is taken from the Wallace or Elderslie Pit and bore, situated a mile further west and close to the edge of the Quarrelton field. In the early record (before 1870) the seams in this pit are identified with the various components of the Thick Coal, but whether on good evidence is doubtful. The highest coal is termed the Nine-foot, a name peculiar to this locality: it is almost certainly the Dykebar Coal, while the two thick seams below probably represent the Upper and Lower Castlehead Coals. The so-called "Minehead" and "Free Craighead" Coals were proved in a 'blind bore' put down from the "Merryhead" position, but their naming is doubtful: they may represent the Newton Coal rather than the two thin seams above. The "whin float" has here risen to a level above all the coals and maintains this general position over the Quarrelton field to the west.

About half a mile south of the Wallace Pit another section (No. 3, Plate III.) is provided by No. 1 bore Auchinlodoment. This is quite reliable, being confirmed by No. 2 bore and also by comparatively recent bores and workings at Craigenfeoch Pit, close at hand. The Auchinlodoment section is the nearest to the Quarrelton field; it is therefore an important point in the Newton-Quarrelton traverse, and, considered together with the other sections, shows in a striking manner the thickening of the coals and the attenuation of the intervening strata as the Quarrelton field is approached.

The Benston Pit section (No. 4, Plate III.) is the only one available for the Quarrelton field itself, apart from the abnormal "doubled" sequence at Craigston already referred to. The old shaft went down 40 fms. to the Thick Coal, but while the order, nomenclature and thickness of the component seams is taken from an old plan at the Home Office, the amount of strata between each coal is conjectural; it cannot, however, be more than a few feet, since this shaft is only 250 yds. distant from the west end of Watson's horizontal section (Plate IV., Fig. 4) where the Thick Coal is still represented as a more or less solid mass. In considering the question of correlation, one last piece of evidence must not be overlooked. The correlations indicated on Plate III. show that the Dykebar Limestone should, around Quarrelton, lie between the Thick Coal and the overlying dolerite sill. This limestone is of much importance to the geologist, but having no economic value—since the position contains much blaes and the limestone ribs are of very inferior quality—it was not taken into account by the early miners. Although unrecorded, it may nevertheless be present between the Thick Coal and the dolerite at Quarrelton. Evidence that it does so occur has been supplied by the discovery of this limestone, typically developed, on the Black Cart above Hagg Mill, west of Johnstone. At this point a thick dolerite sill rests 20 ft. or so above the Limestone, and below the latter a coal has been formerly worked (see p. 11). This exposure is only half a mile north-west of Quarrelton, and the dolerite at each locality may with great probability be assumed to be one and the same sill, for we have no knowledge of more than one such intrusion in the district; nor are sills of this type liable to great changes of level.

This evidence, coupled with that supplied by the bore and pit sections, gives good reason for the belief that the Thick Coal of Quarrelton may be regarded as a combination of several distinct seams which simultaneously thicken and approach one another. This phase is quite local, and west of the field the same process of separation into the component seams as takes place towards the east is met with (see Section 5, Plate III.). A similar change occurs to the north, and from Johnstone to Bridge of Weir and the Clyde the coals become progressively thinner and further apart.

Mode of Origin.—The next consideration is the origin of the 100-ft. or "double" coal. This phenomenon occurs twice over: the first and most striking instance is found half a mile south of Quarrelton village in a strip running north-west about 230 yds. in breadth. The length of this area is at least 400 yds., but its original extent cannot be estimated.

The total area proved is at least 16 acres: it is partly illustrated in Nos. 1 and 3 of Watson's sections (Plate V.). It was here also that the maximum thickness of 100 ft. of coal with partings was met with, and in quoting this record in the description given in the "New Statistical Account of Scotland," already referred to, the significant observation is made that "in the place where the section is taken the coals lie as if they had been cut through, and one half slid over the top of the other"—a remark that is confirmed by a study of Watson's sections. In the most complete of these sections (No. 3) it will be seen that on the south side of the "doubled" strip the coal is less than half its usual thickness. From the title of the section the thin part seems to have been called the "12-ft. Coal," and, as drawn, cannot be more than 20 ft. in thickness at most.

The second duplication of the seam is termed by Watson "ye overlapping coal." This instance is not quite similar to the preceding one:—to quote the words of one of the early writers, ". . . the coal strata have not come into contact; they are separated by a body of sandstone at H. In sinking shaft No. 3 the object was to find the coal at the usual depth, but in passing through the sandstone a very unexpected but fortunate discovery of another large mass of coal was made." *

The phenomena in both cases have all the characteristics of a contemporaneous "want" or "wash-out," for it is a common experience in Scottish mining operations to find that along the edges of such channels the coal is "doubled," or at least is so thick as to make up approximately for the amount removed by denudation in the channel.

It is also not unusual to find the seam thrown out of line and parted by sandstone, etc., as in the case of "ye overlapping coal" of section 3. These "wash-outs" are commonly, and no doubt correctly, ascribed to the action of streams or flood-waters on the unconsolidated material which is now found as coal, and it may be supposed that the "doubling" is due to an immediate re-deposition of the material removed from the channel. It has even been claimed that in some cases the components of the seam can be recognised in reverse order in the upper layer.†

In the case of the Quarrelton Thick Coal there are, however, special circumstances which suggest that the "doubled" and "overlapping" portions are not due to a normal "wash-out." It has already been stated (p. 6) that the Upper Calciferous sediments, in which this coal is included, were accumulated on a highly irregular floor of the Clyde Plateau lavas. Local examples of this fact are not far to seek: in the Howwood basin, less than a mile S.W. of the Quarrelton field, it is known that the slope of the lava surface is at least 8°, or 1 in 7; and that the Thick Coal must have been deposited against this bank of volcanic rock, since at Meikle Corseford the lavas rise from beneath the coal right up to the floor of the Hurlet Limestone (see Fig. 2).‡

Again, in the Newton field, less than 2 miles east of Quarrelton, the slope is slightly above 7°, or 1 in 8.§

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* *The Natural History of the Mineral Kingdom*, by John Williams: Edinburgh 1810. The foregoing transcript is taken from the "Explanation to the Plates" vol. ii., p. 572.

† A typical example of a "wash-out" is described in the *Transactions of the Scottish Institute of Mining Engineers*, vol. vi., c. 1885, p. 235. The discussion following the paper provides much useful information.

‡ There is no question of a fault here. The cores from the diamond bore which supplied the evidence were found to be perfectly "clean": there is also abundant evidence throughout the Glasgow district of the irregularity of the floor.

§ Deduced from the fact that in a bore from the bottom of the Newton pit, the top of the lavas was reached 40 fms. below the Castlehead Lower Coal, which in the bore at Ferguslie Mills, 1250 yds. to the east, lay 120 fms. above the lavas.

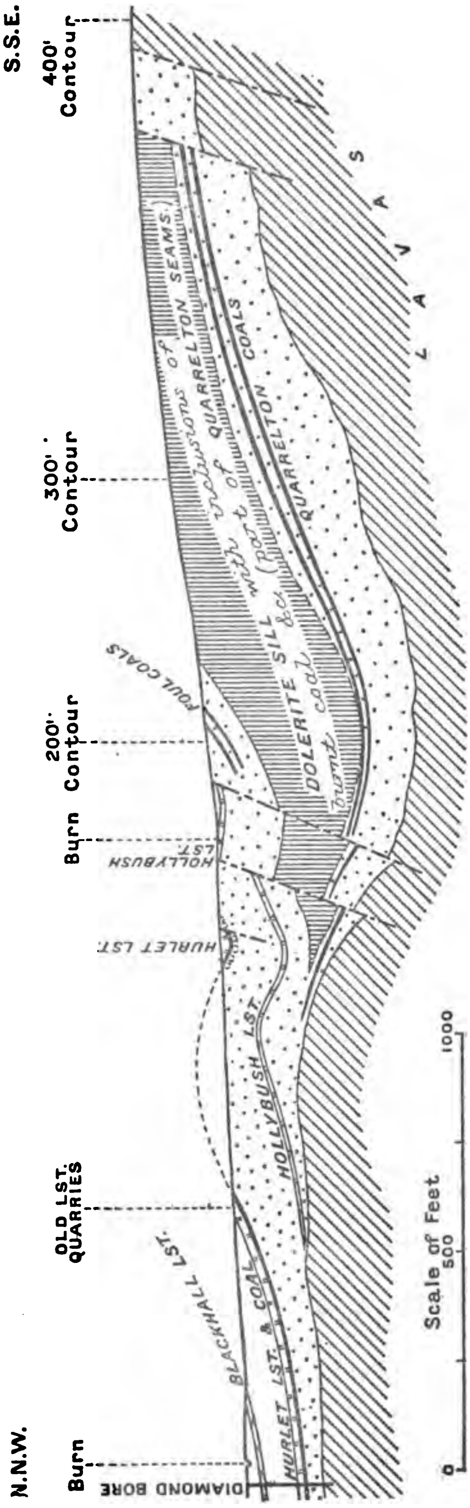

FIG. 2.—Horizontal Section from Meikle Corseford to Whitehill.

These are extreme instances, and no doubt the general slope was considerably less. It, may, however, be said that the inclination was pronounced. Further, it is known from mining evidence already referred to (Auchinlodoment bore and Craigenfeoch and Hallhill Pits) that on the fringe of the Quarrelton field the base of the Thick Coal rests but a few fathoms above the old land surface which, not far away, stood out above the deep marsh in which this great mass of coaly material was slowly gathering.

Here were present all the necessary conditions for a " bog-slide "—ready to be brought about by the least alteration of surface-level caused either by earth-movement, by differential rates of accumulation or through saturation by water. That such a " slide " did take place is not only rendered probable under the special physical conditions but is directly indicated by the remarkable examples of coal-conglomerate found on the site of old workings in the " doubled " coal. These crumpled agglomerations of coaly matter bear every sign of contemporaneous origin, for they consist entirely of coaly material, whereas if the doubling had been due to thrusting or faulting at low angles, one would expect the fragments to be cemented together by calcite, quartz or other extraneous mineral matter. Furthermore, tectonic disturbances of this kind, even on a small scale, are quite unknown in this part of the country.

Summarising the above conclusions, it is therefore suggested that:—

(1) The Quarrelton Thick Coal occupies a comparatively low position in the Upper Calciferous Sandstone sediments, well below the Hollybush Limestone.

(2) It has been formed by the combination of several seams,—the Dykebar Coal, the Upper and Lower Castlehead Coals, and possibly also the Newton Coal: in the Paisley district these are as a rule well separated, but towards Quarrelton the intervening sediments dwindle rapidly while the coals themselves thicken out until they eventually coalesce into one seam, representing 40 or 50 ft. of coaly matter, and known as the Thick Coal.

(3) There are at least two cases of local " doubling "; in one of these the enormous thickness of 100 ft. of coal, or coal with thin clay partings, is attained.

(4) This duplication of the coal was occasioned, not by thrusting, but by a contemporaneous " wash-out " of abnormal character analogous to a recent " bog-slide."

Mining Notes.—The workings in the Thick Coal are of ancient date, some being recorded as early as the year 1634. The original description given in the *Statistical Account of Scotland,* 1793, states that " in the former method of working there were five several floors or storeys, the first, third and fifth stratum being wrought and afterwards so much of the second and fourth as may be done with safety." *

Mining operations must always indeed have presented unusual difficulties, not only from the great thickness of the coal but also on account of its friable nature, the absence of a good roof and its liability to spontaneous combustion. Latterly to these obstacles there was added the danger of breaking into ancient and forgotten workings. This was the cause of the closing of the Benston Pit, the last considerable working, in 1860, after the flooding of the Smiddyhead seam, by which several men were drowned. Since that date four attempts have been made to work the coal, but all on quite a small scale. One of these trials, about the year 1891, was made at the Craigenfeoch or Spout Pit, on the eastern margin of the field, where the Thick Coal has begun to split up (see section of the adjacent Auchinlodoment bore, No. 3, Plate III.). The shaft was situated on the south side of the by-road east of Spout Quarry, Windyhill: it was 21½ fms. deep, and an old "waste" was found close to the pit bottom. Through this a stone mine was driven N.N.E., dipping 1 in 8, and from this mine two coals were wrought: one termed the "Ironhead"; the other—15 ft. below—the "Merryhead": it is, however, quite uncertain whether these identifications were reliable. Sections of the two seams are given below.

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* Vol. vii., 1793, p. 80.

Coals wrought at Craigenfeoch or Spout Pit.

		Ft.	In.
"Merryhead" Seam, 2 ft. 5 in.	Fakes (roof)	2	2
	Coal, splint	0	7
	Coal, gas	0	7
	Coal, free	1	3
	Fakes (holing)		

		Ft.	In.
"Ironhead" Seam	Coal	0	4
	Sandstone	1	0
	Coal	0	8
	Fireclay	0	4
	Coal	0	8
	Sandstone	0	4
	Coal	1	0
	Fireclay		

A condensed version of a bore put down, apparently from the so-called "Merryhead," is given below:*

Bore in Craigenfeoch Pit.

	Fms.	Ft.	In.
Strata	8	0	0
Coal	0	2	6
Fireclay	0	1	0
Coal	0	5	6
Blaes and Coal	0	4	0
Coal, gas	0	1	0
Coal	0	2	0
Fakes, kingle ribs and fireclay.			

The thick seams of coal in the above section are in general agreement with those in the lower part of the Auchinlodoment bore, close at hand. They were probably of inferior quality, since no subsequent attempt seems to have been made to work them. About the same time (1890), a trial was made in the Quarrelton field proper. The coal was known to lie 30 ft. thick at a depth of 12 to 20 fms. on the north side of the "Paisley Ruck," a few hundred yards west of Quarrelton village. A stone mine was put down in the middle of what is now the public park, and dipping S.W. at 1 in 4, cut the Thick Coal under "Hunters' Field." A 5-ft. working was opened in the heart of the seam, but the area actually wrought was less than 50 yds. square. According to local information the coal was powdery and broken and also full of pyrites, causing spontaneous combustion. The workings had to be flooded, but after the water was pumped out the fire started again. Such adverse conditions naturally put a speedy ending to mining operations.

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* According to a record in the Dalzell MSS., to be consulted in the Mitchell Library, Glasgow,—"this bore was put down from the pavement of the 'Straggler' Seam." This name was probably in temporary use before any definite correlation had been attempted.

An unsuccessful attempt was also made to re-open Hallhill Pit, 1 mile S.W. of Quarrelton: a memorandum taken at the time gives the section as:—

STRATA AT HALLHILL PIT, MILLIKEN PARK.

		Fms.	Ft.	In.
	Surface and strata	21	0	0
COAL, 3 ft. 9 in.	COAL	0	2	0
	Parting	0	0	1
	COAL	0	1	8
	Strata	4	3	0
	COAL	0	4	0

The bottom coal is said to be 10 ft. thick. in Montgomery's version.*

A blind bore put down from the pit bottom after the partial clearing of the shaft found 2 ft. of coaly blaes at 3½ fms. and at 8 fms. 4 ft. reached the lavas, in which it continued till stopped at 26½ fms.

Some twenty years ago a surface opening, known locally as "Black's opencast," was made at a point 400 yds. east of Craigston farmhouse. Part of the coal was laid open but the venture was not a success, much of the seam having been already removed in the earlier workings with which the ground is riddled.

This opening appears to have yielded small supplies of coal for some years, until the frequency of dangerous falls caused further operations to be abandoned. The coal is said to have been much broken and disposed in lenticular layers: the face is now entirely covered up, but there is abundant small coal, both "free" and "smithy" on the waste heaps, while fragments of gas coal are not uncommon. Much of the debris, as already mentioned, is in the condition of "coal-conglomerate" (see p. 25).

As regards future operations, the advisability of any further trial in the Quarrelton field itself—*i.e.* south of the G. & S.W. Railway and up to High Craig and Windyhill—is doubtful. The coal is there at a maximum thickness, but the ground is covered in every direction with old workings, and although the sites of most of the shafts are known, the area of coal actually taken out is not accurately defined. There may well be isolated blocks of material still unwrought, but their detection would necessitate frequent and careful boring: perhaps the best locality for a preliminary trial would be to the west of Windyhill, for here there is little evidence of old workings, and since the ground lies high, water trouble, at any rate, should be at a minimum.

* "Essay on the Geology of Renfrewshire and North Ayrshire," *Trans. Highland and Agric. Soc.* Series II., vol. vi., 1839, p. 421.

In outlying districts, one of the best sites would appear to be at the side of the River Cart above Hagg Mill, Johnstone. The Dykebar Seam, the highest leaf of the Thick Coal, is known to crop here and has been wrought, but the underlying beds do not seem to have been tried, probably because they are separated from the higher coal by a considerable thickness of sandstone, and, owing to a large fault with downthrow to north, do not reach the surface. A word of caution may be added as to the quality of the coal. Most of it is probably inferior, although there may be ribs of high-grade material. The occurrence of anthracite might be expected by those who believe in the production of this class of coal by a contiguous "whin float"; but as a matter of fact, the alteration caused by the overlying dolerite is confined merely to the production of "blind coal" which may be seen resting directly on the free-burning variety, immediately beneath the "whin" at the old Lex Quarries, Elderslie, and at Barr Hill, in the grounds of Milliken House, Johnstone. R. G. C.

CHAPTER III.

JOHNSTONE AND PAISLEY DISTRICT—*continued.*

Carboniferous Limestone Series.

LOWER LIMESTONE GROUP.

A full sequence of the strata in this group is present although the total thickness is not so great as in the type district of Hurlet. The succession, also given in graphic form in Fig. 1, is as follows:—

(See also Plate VIII.).

	Fms.	Ft.	In.
Top Hosie Limestone, 10 in. to 2 ft.	about 0	4	6
Strata—variable, from a few inches upwards			
Second Hosie Limestone, about 2 ft.			
Strata	1	0	0
Lillie's Shale Coal	0	2	0
Strata	3	3	0
Mid Hosie Limestone	0	1	6
Strata	3	0	0
Main Hosie Limestone	0	1	0
Strata	4	0	0
Limy claybands and shaly blaes with Entomostraca	1	0	0
Strata	8	0	0
Neilson Shell-bed	0	3	0
Blackhall Limestone	0	1	6
Strata	4	0	0
Coal	0	1	0
Strata	3	0	0
Hurlet Limestone	1	0	0
Hurlet Coal	0	4	0

As a whole, the group reaches its maximum thickness in the north-eastern part of the district, measuring nearly 60 fms. in the Greenhead boring near Renfrew. A steady attenuation takes place towards the south-west, and at Bridge of Weir the thickness is reduced to 30 fms. With the Hurlet Limestone itself the case is exactly reversed, for while near Renfrew and in the northern part of the district generally, this seam is only 3 to 4 ft. thick, it reaches 30 ft. near Bridge of Weir, and quite as much at Limecraigs, south of Paisley.

From an economic point of view, only two members of the group are, at the present time, of any real importance. These are—the Lillie's Shale Coal, which has been extensively worked as an oil producer, and the Hurlet Coal, in which little has yet been done, large areas of the seam still remaining intact. The Hurlet Limestone has also been wrought, but is now not so valuable as formerly.

The best natural exposures are undoubtedly those in the neighbourhood of the river Gryfe, below Bridge of Weir, where every member of the sequence with the exception of the Hurlet Coal can be seen. Smaller sections occur near Howwood, and there is a notable exposure of the Hurlet Limestone at Limecraigs, but beyond these all our information is derived from bores and mining evidence, of which there is an abundance.

The Hurlet Seam is one of the most important datum lines within the Carboniferous formation. It attained this position originally on economic grounds, since it was the lowest workable seam which could be recognised over wide areas in the West of Scotland; it was consequently taken as the base of the Carboniferous Limestone Series. In recent years its value as a divisional line has, however, been strongly criticised * on account of the undoubted occurrence beneath the Hurlet position of several limestones containing marine fossils identical with those found above this line. While this is certainly the case, the retention of the Hurlet Seam as a base-line for the Limestone Measures can be defended on other palæontological grounds, for the researches of Dr. Kidston have shown that an important "plant-break" occurs about the same position. There is also the fact—amply verified within the last few years—that a great transgression across the older rocks took place over a great part of the Central Valley at the time of the deposition of the Hurlet Limestone. This unconformity and similar phenomena in Millstone Grit times, mark the two principal periods of crustal disturbance in the Scottish Carboniferous rocks, and the redistribution of the land-masses thereby indicated is no doubt largely responsible for the "plant-breaks" found at these two horizons.

These reasons, coupled with the economic argument, sufficiently justify the retention of the Hurlet Seam as the base-line of the Carboniferous Limestone Series. A line must be drawn somewhere, in order to bring out the geological structure on the map: the selection of any other position would be less scientific, less important economically, and, relatively, purely local in character.†

The Hurlet Limestone and Coal have, in this district, no very special or peculiar characters, although certain features are more or less persistent. The blaes that rest upon the Limestone are practically unfossiliferous: the limestone itself is of grey, crinoidal type, but where very thick—as at Bridge of Weir and Limecraigs—the upper layers are "calmy" or intercalated with crinoidal shales (Howwood). The Coal is invariably pyritous and soft, and the "alum shale" in the roof may often show a fairly rich assemblage of lamellibranchs and brachiopods (Howwood and Campsie), or, quite as often, be almost unfossiliferous, as at Arkleston, Hurlet and Blackhall, at which localities *Lingula* only can be found.

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* James Neilson, "Notes on the Geological Survey Memoir," *Trans. Geol. Soc. Glasgow*, vol. xiv. (Part 3), 1913, p. 334.

† Mr. Neilson suggests (*op. cit.*, p. 324) that the divisional line between the Carboniferous Limestone and Calciferous faunas lies "somewhere within the volcanic rocks." He leaves, quite rightly, its exact position undecided, for in Scotland no sharp division in the marine *fauna* comparable with that in the *flora* has ever been observed. On the contrary, all the evidence is indicative of a gradual faunal change, due partly so migration, partly to evolution. This holds from the marine fauna of the Liddesdale Cement Stones up to the Millstone Grit. It would be manifestly impossible to construct an intelligible map on such uncertain data.

From an economic standpoint the Seam is best developed to the west and north of Paisley, where several attempts to work it have been made. The last trial was about the year 1896, in the Blackstone Pits, about half a mile south of Houston Station. These pits were primarily intended to work the Johnstone Clayband Ironstone at 40 fms., and the Lillie's Shale Coal at 52 fms., but the main shaft was continued to a depth of 79 fms., and a stone mine driven from that level westwards through a 22-fm. fault with a downthrow to the east struck the Hurlet Seam on the further side of the upthrow. A short mine was also driven through the fault from the Ironstone workings, and a "blind pit" sunk from this mine to the Hurlet Seam 30 fms. below. From the data supplied by the main shaft and blind pit, Mr. R. Waddell, the manager, compiled a careful section, giving all the strata from the Lillie's Shale Coal to the Hurlet Seam. The section at Blackstone Pits is given as follows:—

		Ft.	In.
HURLET SEAM	LIMESTONE (upper portion)	2	4
	LIMESTONE (lower portion)	2	10
	Limy blaes	0	3
	Blaes	0	7
	COAL	4	2
	Fireclay		

The above appears to be a good average section of the Hurlet Seam for this part of the district. The following details, derived from the journals of bores in the neighbourhood, may be quoted as of interest:—

1. Bore at N.W. corner of Paisley Racecourse.
   Limestone, 2 ft. 10 in.; blaes, 7 in.; coal, 3 ft. 9 in.; at 89 fms.
2. On right bank of the Black Cart, south of Inchinnan.
   Limestone, 4 ft. 10 in.; blaes, 5 in.; coal, 3 ft.
3. 300 yds. east of Brownsfield.
   Limestone, 4 ft.; blaes, 4 in.; coal, 4 ft. 6 in.; at 55 fms.
4. South of Greenhead farm-house.
   Limestone, 3 ft. 2 in.; coal, 1 ft. 1 in.; at 85 fms.
5. Netherfield.
   Limestone, 6 ft. 6 in.; blaes, 6 in.; coal, 3 ft. 8½ in.; at 51½ fms.
6. Hareshaw.
   Limestone, 1 ft. 6 in.; coal, 3 ft. 10 in.; at 33 fms.

The Seam was wrought on a small scale about the year 1870, on the estate of South Barr. The two pits, 30 fms. in depth, were situated on either side of the road north of Wardhouse Smithy: an average section of the working gave:—limestone, 2 ft. 4 in.; blaes, 15 in.; coal, 3 ft. 9 in. The strata rose towards the north at 1 in 15, in which direction old pits, 20 fms. deep, are known to exist. The workings were cut off to the west by a 70-fm. downthrow fault, bringing the Johnstone Clayband on a level with the Hurlet Seam, and a trial was made in this ironstone before the pits were finally abandoned. The Seam was proved further to the west in two bores on North Commonside:—one by the side of the railway got limestone 3 ft. and coal 4 ft. 10 in. at 46 fms.; the other, 700 yds. west of the farm-house, found limestone 3 ft. 2 in. and coal 4 ft. at 47 fms.

From the foregoing details, it is evident that the Hurlet Coal is well developed and constant in thickness in the ground to the north and west of Paisley, where an area of at least 6 square miles still remains untouched, and although the coal cannot be expected to be of high quality, it may well be worth attention in the future. The strata are generally gently inclined and not greatly faulted, and the limestone would provide an excellent roof to the workings. Indeed this seam is the most important mineral reserve in western Renfrewshire.

In the south-west part of the Paisley district, the Hurlet Seam is less valuable, the limestone becoming abnormally thick and the coal thin. Around Kaimhill, east of Bridge of Weir, many shallow pits, not exceeding 22 fms., were in operation before 1870; none of the workings appear to have extended beyond the Locher Water. One of these pits, 500 yds. west of Kaimhill, also worked a local clayband ironstone, 8 fms. above the Hurlet Coal. The upper part of the Limestone is still visible on either side of the river Gryfe, below Coalbog; the best section lies on the right bank due north of Kaimhill, showing 30 ft. of grey "calmy" limestone flags with scattered brachiopods and crinoid debris. Day-holes to the old workings are seen at the foot of the cliff. Fragments of coal are to be found on the waste-heaps below, but neither the Coal nor the main post of limestone can now be seen in place. In a neighbouring bore by the mill-lade south-west of Crosslea House, the section was—limestone with blaes partings, 15 ft.; coal, 2 ft. 10 in. The records of two early sinkings in this neighbourhood give (1) at Goldenlee—limestone 7 ft., "till" 1 ft., coal 2 ft.; and (2) at Kaimhill—limestone 7 ft., "till" 2 ft., coal 2 ft. 6 in.*

Nearer Johnstone, other old workings in the Hurlet Seam are also known. One of these pits, 40 fms. in depth, lay N.W. of Darluth cottages, between Windyhill and West Fulton, and a considerable area was wrought here, the workings being limited to the north by a 20-fm. upthrow. The coal appears to have been of considerable thickness; in a bore on the north side of the 20-fm. fault near West Fulton, it is given as 4 ft. with a 1-in. rib of pyrites in the centre.

The Windyhill Pit, 200 yds. south of the farm-house, was 42 fms. in depth, and west of Merchiston House at least three other shallow pits are known. An old mining report gives the section in these workings thus:—

	Ft.	In.
LIMESTONE	1	6
Blaes	9 in. to 3	0
⎧Good House COAL	1	3
⎩Hard COAL	1	5

The public well in Houston Square, Johnstone, is said to have passed through the Hurlet Limestone at 10 fms., and a note on the original Survey Map states that, south of the Square, "in sinking wells here old workings in the Hurlet Coal were reached at no great depth," but no further information is obtainable.

A well-defined basin of the Hurlet Seam, rather over a mile in length and a third of a mile in breadth, lies between Howwood and

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* Wm. Montgomery "On the Geology of Renfrewshire, etc.," *Trans. Highland and Agric. Soc.* Series II., vol. vi., 1839, p. 439.

Milliken Park, the axis of the syncline trending north-east. The outcrop on the south and west is continuous and marked by a line of abandoned quarries: on the north-west side of the basin the strata are cut off by the crush-line known as the "Paisley Ruck," and are truncated to the east by a large upthrow fault.

The data obtained here are of great interest to the geologist, from their value in the identification of this seam in the Ayrshire sequence, but are of little economic importance, since the old workings occupy nearly all the ground. The principal pit, 30 fms. deep, was at Corseford in the centre of the basin, and from it was taken out all the coal between the Black Cart Water and Meikle Corseford farm-house. The average section in the Corseford Pit was as below:—

	Ft.	In.
LIMESTONE	3	6
Hard blaes . . .	1 to 6	0
HARD COAL	1	6
Holing	0	6
BOTTOM COAL . . .	1	6
Fireclay		

In the foregoing section only the lower or main post of limestone is given, and the thickness of the coal is perhaps overstated. Much more limestone, intercalated with blaes, is actually present, and a better account of the whole seam is supplied by the Meikle Corseford diamond bore, put down at the burnside and immediately beyond the limit of the old workings, in 1913. Examination of the cores from this bore gave the following sequence:—

SECTION OF THE HURLET SEAM IN THE MEIKLE CORSEFORD BORE.

		Ft.	In.
	Dark blaes and balls: small *Lingula* . .	4	0
HURLET LIMESTONE The bottom bed is the "main post" (formerly worked)	Limy blaes with LIMESTONE ribs, both full of crinoid stems and fragments up to ½ in. in diameter: occasional small Producti and *Sanguinolites costellatus* with a *Tabulipora* layer near the top	31	6
	Hard creamy-grey crinoidal LIMESTONE . .	5	6
"Alum Shale"	Dark crinoidal blaes, crushed Producti, etc. .	1	0
	Dark blaes crowded with (?) *Cypricardia tricostata*	0	3
	Dark crinoidal blaes with crushed Producti, etc. .	3	3
HURLET COAL	Coaly blaes.	0	4
	Soft bright COAL	1	4
	Coaly blaes	0	8
	Fireclay		

In the old quarries to the south-east along the Swinetrees Burn 25 ft. of the upper "blaes and limestone ribs" are still visible. Further up stream, and 300 yds. S.E. of Meikle Corseford farm-steading, the Hurlet Seam, with Calciferous marls on either side, appears again in a small synclinal fold: the limestone has been quarried out, but the alum shale is well exposed, though most of the coal below has been removed. The lamellibranch band in the shale is particularly well seen here.

Little information is now obtainable regarding the old shafts at the northern end of the main Corseford basin: the coal was apparently thicker here, for a bore put down at Little Corseford about

1850 records—limestone with partings, 8 ft. 3 in.; "till," 2 ft. 3½ in.; coal, 3 ft. 10 in.—the coal at a depth of 10 fms. 4 ft.

The limy blaes overlying the main post can be seen along the Black Cart Water due north of Howwood; it is here involved in the "Paisley Ruck" and the strata are vertical and much shattered.

Another small infold of the Hurlet Seam appears in Midtown Wood, south of Midtownfield Bleach Works. The beds dip south-east at about 20° and were worked both opencast and by mining: the workings cannot have been carried far in, as the Calciferous strata are faulted up on the south side of the Wood. The upper part of the Seam appears in the old quarry, where there is a face, 18 ft. high, of flaggy limestone with partings of blaes, overlain by dark unfossiliferous blaes with clayband ironstone ribs, the junction being quite sharp as in the Meikle Corseford bore.

The Hurlet strata reappear at Limecraigs, 2¼ miles S.S.W. of Paisley Cross, where they lie in the centre of a well-marked syncline, as already described in the chapter dealing with the Calciferous Sandstone sediments (p. 5). Although quarries were in operation here more than a century ago, no definite correlation of the Hurlet or of the underlying limestones seems to have been made until 1913, when a paper on the limestones of the Glasgow district was communicated to the Glasgow Geological Society by Messrs. P. Macnair and H. R. J. Conacher.* The evidence for the identification of the Hurlet of this locality rests not so much upon the somewhat indefinite and abnormal characters of the limestone, as on its relations to the underlying strata, of whose position in the sequence there can be no reasonable doubt. The limestone is unusually thick; it is also distinctly "calmy" and flaggy as at Bridge of Weir, and fossils (chiefly crinoid debris and small Producti) are relatively scarce. A thickness of at least 30 ft. is exposed in the disused quarry at Limecraigs and the base is not visible. There are said to be coal workings beneath the quarry, but these are now completely obscured by debris.

Between Paisley and Renfrew, south of Porterfield, workings in the Hurlet Coal were carried on between 1770 and 1800. The sites of seven of these old pits are known, but details of the Seam are unobtainable. The outcrop, beneath 100 ft. of surface-deposits, lay 600 yds. S.S.W. of Porterfield, at right angles to the present railway line; the strata dipping N.E. at 19°. Near the river the workings must have been stopped by the Paisley Ruck, which has been proved here in recent borings (p. 46). Another small working was carried on earlier than the year 1870 north of Elderslie, between Muirhead and Barskiven Hill. The coal here was at "half-edge" (45°) owing to the proximity of the Paisley Ruck, and the heavy inclination must have soon brought the workings to a close.

In the western part of the district a coal, lying 2 or 3 fms. above the top of the Hurlet Limestone, has been observed at several localities. This seam is in much the same position as the Wilsontown Smithy Coal of Lanarkshire. In the West Fulton bore the coal was 14 in. thick, but elsewhere is less, measuring 11 in. in the Meikle Corseford boring and 6 in. in the river Gryfe near Bridge of Weir, where it can be seen at low water on the left bank of the stream opposite the limestone cliff north of Kaimhill. *Lingula* and fish scales are abundant in the roof of this coal; there are also ribs of clayband ironstone above and below.* One of these was 10 in. thick in pits to the south-west where the ironstone and coal were wrought together about the year 1856. The coal is soft and probably not good, and does not appear to have been raised elsewhere in the district.

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* "The Stratigraphy of the Limestones lying immediately above the Calciferous Lavas in the Glasgow District," by Peter Macnair and Harry R. J. Conacher. *Trans. Geol. Soc. Glasgow*, vol. xv. (Part 1), 1914, p. 39.

The Blackhall Limestone is a very constant horizon in the Paisley district and is invariably recorded in the numerous bores which have passed through the position. It possesses strongly marked characters and is thus readily recognised among the other members of the Lower Limestone Group. At the top lies a fossiliferous blaes—the Neilson Shell-bed—crowded with marine fossils. While none of the forms seem peculiar to this horizon their great variety and excellent preservation are remarkable. The assemblage at Campsie and Thorntonhall, which appears to be essentially the same as that found in the Paisley district, has been fully described by Mr. James Neilson, who has rightly emphasised its importance for correlation purposes.†

Below this shell-bed lies the Blackhall Limestone proper—a hard crinoidal rock with small scattered Zaphrentid corals: beneath are several layers of shale and ironstone, crowded with minute entomostraca (*Leperditia*) and often showing streaks of coal. Immediately below is a nodule-bed, followed by further ribs of limy entomostracan ironstone. This sequence everywhere characterises the Blackhall Limestone position.

Three natural exposures are known west and south-west of Paisley. The best of these is found on the left bank of the river Gryfe, nearly half a mile above Linningford Bridge, Crosslee, where the whole succession is seen in a cliff section, although accessible in part only at low water: the details of this section are given below.

SECTION OF THE BLACKHALL LIMESTONE IN THE RIVER GRYFE.

(See also Plate VIII., Section 4.)

		Ft.	In.
	Dark blaes	10	0
NEILSON SHELL-BED	Limy blaes, full of small marine organisms :—Goniatites common : also *Orthoceras*, *Euomphalus*, small Brachiopoda (especially *Chonetes*); crinoid debris, etc.	3	0
BLACKHALL LIMESTONE	Hard grey crinoidal LIMESTONE, pale ochreous weathering : *Zaphrentis constricta* and *Z. disjuncta*	1	6
	Grey blaes, pyritous, with gypsum efflorescence, small fish scales and *Leperditia*	0	2
	Soft pale fireclay and blaes . . . 3 in. to	1	0
	Shaly blaes : pyritous and efflorescent ; small fish scales and *Leperditia*	0	3
	Green marl with mamillated, irregular cement nodules	1	0
	Platy shale and limy bands with *Leperditia*	0	6
	Soft green marl	0	3
	Striped grey entomostracan LIMESTONE with occasional minute worm-tubes . . . 1 in. to	0	6
	Blaes parting		
	Grey entomostracan LIMESTONE, bright yellow weathering 6 in. to	0	9
	Greenish-grey fireclay	0	6

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* These ironstones represent the Househill Claybands of Hurlet and Nitshill.

† "Notes on the Geological Survey Memoir," *Trans. Geol. Soc. Glasgow*, vol. xiv. (Part 3), 1913, p. 327.

		Ft.	In.
	Dark fireclay	0	4
	Foul Coal and coaly blaes	0	6
	Grey fireclay	0	3
	Blaes and clayband ironstone balls *	12	0
	Black slaty blaes ; *Lingula* and fish scales	2	0
Wilsontown Smithy Coal position	Bright Coal	0	6
	Black fireclay	1	0
	Blaes with ironstone balls, with a 3-in. rib of entomostracan Limestone	2	0

The foregoing section is given in full detail since it is incomparably the best exposure in Renfrewshire of a horizon of great interest to the stratigrapher and the palæontologist. In the three sections east of Paisley—Blackhall, Ross Hall Mains and Hurlet—the sequence is very similar, though the green marl and entomostracan limestone differ in thickness, and very little is seen of the Neilson Shell-bed (see p. 53). Further down the Gryfe, on the right bank at the bend to the north below Linningford Bridge, Crosslee, the Blackhall position is repeated by faulting: the higher marine beds are here mostly eroded, only the basal layer of the limestone being now visible; the underlying entomostracan strata are however well seen. There is an indifferent exposure near Howwood, in the Midtown Burn immediately below Crossford Mill, where the Neilson Shell-bed is the most conspicuous feature. A full sequence was obtained in the Meikle Corseford diamond bore, the details being practically identical with those observed in the Gryfe section above Crosslee. The position has also been recorded in many bores to the N.W. of Paisley (Racecourse, Netherfield, Fulwood, East and West Fulton, Hareshaw, N. Commonside, Inchinnan, Brownsfield, etc.) but the underlying Househill Clayband Ironstones, still mined near Hurlet, have never been met with in workable thickness in these borings.

A well-defined group of limy entomostracan ironstones and "kingles," with partings of blaes and shaly blaes, lies 10 to 15 fms. above the Blackhall Limestone. These beds are well exposed on the river Gryfe, 550 yds. above Crosslee Bridge, where they reach a total thickness of about 6 ft. Smaller exposures occur in the Locher Water north of the railway at Locher Mill: here there are two outcrops repeated by faulting, the highest layer of the Blackhall Limestone being brought up between them. The entomostraca in these beds appear to be small species of *Leperditia* similar to those found beneath the Blackhall Limestone. This horizon is a constant feature both in Renfrewshire and along the south side of the Lanarkshire basin.

Next in order of sequence are the four Hosie Limestones. Of these, both the *Mid* and *Main* (or lowest) *Hosie Limestone* are thin, though quite persistent, in this district. They are seen in the Gryfe above Crosslee (Plate VIII., Section 4) and also at several points in the Locher Mill Burn, to the south and south-east. In the Gryfe section, on the right bank of the stream 300 yds. S.W. of Crosslee Bridge, the Main Hosie is from 8 to 12 in. thick, hard, and yellowish-weathering; it contains throughout much crinoid debris, and, in the top layers and immediately overlying blaes, minute gasteropods (*Ptychomphalina*). The Mid Hosie lies 26 ft. higher up: it is about 18 in. in thickness, also yellow-weathering, but, except for crinoid debris at the base, without fossils. The intervening blaes contains occasional bands of small brachiopods, etc. and—6 ft. above the Main Hosie—impressions of small indeterminable Goniatites are abundant. These also occur above the Mid Hosie, but on that horizon are best seen in the bed of the burn opposite Locherside Cottage, where their iridescent colouring is very striking. This exposure is due to an east-and-west fault throwing down to north,—a continuation of the line of dislocation along the Gryfe, at and above the ford at Coalbog.

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* Many of these are petrifactions of *Stigmaria ficoides* showing internal structure. This fact was discovered by Mr. H. R. J. Conacher. See *Trans. Geol. Soc. Glasgow*, vol. xvi. (Part 1), 1916, p. 107.

Below the bridge at Locherside there is a good outcrop of the Mid Hosie, with the Goniatite band—also containing *Sanguinolites costellatus*—above. Further upstream, and about 250 yds. below the railway viaduct, the Main Hosie appears; the remarkably thin and lenticular nature of this outcrop is due to a small fault running parallel with the bank, and partly cutting out the limestone. Goniatites are again seen above the limestone but these fossils are purely local and should not be taken as a characteristic feature.

Elsewhere in the Paisley district only one other section of either of these limestones is known. This occurs within the grounds of Milliken House, at and above the mouth of the stream falling into the Black Cart near Johnstone North Station. The Mid Hosie is seen here, but the exposure is poor and of little importance. Note should be taken of the fact that the *Hosie Sandstone* which is so prominent beneath the Main Hosie Limestone east of Paisley, disappears entirely to the west of that town.

The Lillie's Shale Coal is a seam with special characters, which have rendered it of some economic importance. It averages 2 ft. in thickness, made up of a foot of coal resting upon a foot of "shale," each of these occasionally increasing to 1½ ft. As seen in the stream sections at Locher Mill, about to be described, the coal is soft and bright, and the "shale" is a micaceous, laminated parrot, with films of bright coal running through it. It shows a brown streak, but does not curl under the knife, and except in its capacity for yielding oil under distillation, in no way resembles the true oil-shales of the Lothians.

The Lillie's seam, as a coal, is of an exceedingly persistent character. Hardly ever exceeding 2 ft., and frequently only a few inches in thickness, it can be traced almost continuously as far east as the Bathgate region. Nevertheless, with the exception of the Campsie area—where it is an inferior parroty shale—it is only in the Paisley-Johnstone district that it becomes a commercial subject as a source of oil. For that purpose the seam has been extensively worked to the north of Johnstone (Milliken and Clippens) and also at Linwood, Blackstone and Walkinshaw. At least a square mile has been taken out to the west and south-west of Clippens, the workings being carried right up to the outcrop. In this part of the district little of the field can remain untouched: probably the only area of any size lies north of Linwood, between Middleton and Blackstone House. Here, from the outcrop down to a depth of about 80 fms., there is about half a square mile in which only one small trial has been made;—a pit having been sunk at a point 500 yds. N.W. of Middleton farm-house, 41 fms. to the shale; but so many "wants" were encountered that the attempt was abandoned. This adverse feature is probably quite local, and the field may well be worth further exploration. The largest extent of unworked ground lies west of Inchinnan. Here the seam occupies a basin, extending over a square mile from its outcrop down to the deepest part south of Bottom farm-house, where it must lie at a depth of 70 fms. Two bores have been put down in this basin, one of which (in 1869) south of Greenhead, found 1 ft. of coal and blaes resting on 22 in. of oil-shale, at a depth of 35 fms.; the other—at the point where the road to Allans leaves the main highway—got 23 in. of shale at the same depth: in both these bores the overlying coal was in two leaves, separated by a 40-ft. bed of sandstone. The shale is thicker here than at Clippens, as is also the case at Walkinshaw, not far to the south, where the coal and shale measured 16 in.

The yield of oil from the shale in the Clippens and Milliken workings was 40 gallons or more per ton.* As regards sulphate of ammonia (a by-product of great importance at the present time) we have no figures, but few of these "parrot" shales yield more than 20 lbs. per ton.

While ancient opencast workings can still be traced in the plantations west of Houston and by the stream near West Fulton, only one exposure of the Shale Coal is now visible. This occurs on the left bank of the stream at Locher Mill, between Bridge of Weir and Johnstone. There are old workings here, and only fragments of the coal can be found, but the shale itself is present, resting upon a bed of hard sandstone: its tough, flaggy character is well marked, and the lines of jet-like coal in the micaceous "parrot" are very noticeable.

Above the Lillie's Coal position 5½ ft. of blaes can be seen, showing near the top a rib of entomostracan limestone with "sun-cracks"; this rests upon blaes full of crushed lamellibranchs.

The Second Hosie Limestone lies so close beneath the Cement or Top Hosie that the two form practically one seam in this district. The evidence for the existence of this limestone as an independent member of the sequence rests partly on bores and partly on the indifferent exposures found at Locher Mill. Here, just above the mill-dam, a 3-in. bed of limy blaes, full of small crushed Producti and crinoid debris, lies 5½ ft. above the Lillie's Coal. This blaes is quite different from that associated with the Cement above, and evidently marks the base of a normal crinoidal limestone, formerly quarried along with the Cement; the debris of the latter is seen in abundance on the right bank of the stream. Two bores a few hundred yards to the east record, respectively, 4 ft. 1 in. and 4 ft. 6 in. of limestone, 6 ft. above the Shale Coal: this is far too thick to represent the Cement alone, and is evidently due to the presence of another limestone—the 2nd Hosie—underneath; the two having been reckoned together as one seam.

The *Cement* or *Top Hosie Limestone,* which marks the upper limit of the Lower Limestone Group, is one of the most characteristic limestones in the west of Scotland. It varies from 10 in. to 2 ft. in thickness and is of a dark "calmy" nature with cream-coloured weathering and a sub-vitreous fracture. Fossils are scattered throughout the rock but are largely concentrated along lines of bedding: they are well preserved and their white shells contrast strongly with the dark matrix. They consist for the most part of small Brachiopoda—Rhynchonellids and Producti—and Gasteropoda—*Euphemus*, etc. In the platy blaes associated with the limestone the small lamellibranch *Posidonomya corrugata* occurs in profusion. The characters described above invariably accompany the Cement in the west of Scotland—Campsie, East Kilbride, Strathaven, Carluke, etc.—and are typically developed in the Paisley district.

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* The spec. gr. of the crude oil was ·909, which is high for a shale product; it gave less burning oil but more lubricating oil than a normal Lothians shale. The loss in refining was also greater. [See analyses in "The Oil-Shales of the Lothians" (*Mem. Geol. Surv.*), 1912, pp. 155, 157.]

From the number of abandoned quarries seen in the area, the Cement appears to have been in considerable demand in former times. The limestone is not known *in situ*, but fragments of the bed, with its accompanying *Posidonomya corrugata* shales, can be found in abundance on the waste heaps above and below the dam at Locher Mill, Bridge of Weir.

Loose debris is also plentiful at the old opencast working 400 yds. N.W. of Houston Station, and along the burn N.W. of West Fulton. In the flat carse lands north of Paisley and Johnstone the outcrop of this horizon is everywhere buried beneath surface deposits, but the limestone has been proved in a number of bores. The available opencast workings have been exhausted, and operations in this seam would now have to be carried on underground. Its chief value at the present time is probably as an index-mark for the Lillie's Shale Coal, 6 to 10 ft. below.

LIMESTONE COAL GROUP.

A good record of this important mineral series is supplied by the shaft section of No. 2 Pit, Abercorn, nearly 2 miles west of Paisley Cross. The details, as tabulated below, may be considered to apply to the district in general, the data regarding the Index Limestone being taken from adjacent bores.

General Section of the Limestone Coal Group in the Paisley and Johnstone District.

		Fms.	Ft.	In.
	Index Limestone	0	5	0
	Strata	20	0	0
Possil Sub-Group of the Glasgow Area.	Coal	0	1	1
	Strata	0	4	0
	Rough Coal	0	2	0
	Sandstone	4	3	0
	Splint Coal	0	2	0
	Blaes	1	4	0
	Coal	0	1	6
	Strata	11	0	0
	Stony Coal	0	1	8
	Strata	2	3	0
	Main Coal	0	2	9
	Strata	2	0	0
	Steam or Soft Coal	0	2	6
	Strata	4	0	0
	Turf or Borestone Coal	0	2	0
	Strata	28	5	0

		Fms.	Ft.	In.
GARSCADDEN SUB-GROUP.	"LOGAN'S BANDS"	12	3	0
	UPPER BLACKBAND IRONSTONE	0	1	0
	Strata	8	0	0
	LOWER BLACKBAND IRONSTONE	0	1	0
	Strata	43	3	0
	JOHNSTONE CLAYBAND IRONSTONE	0	1	0
	Strata	9	0	0
	TOP HOSIE LIMESTONE			

(See also Plate VIII., Section 2.)

Of the foregoing sequence, the Upper or Possil sub-group of coals is practically confined to the small but interesting syncline at Linclive, between Linwood and Paisley. The underlying Garscadden sub-group of ironstones, however, covers 5 or 6 sq. miles between Johnstone and Renfrew, and west of the latter town reappears in a basin lying between two large faults. Extensive mining operations have been carried on in these beds, and the last remaining pit, at Walkinshaw, has but recently been closed down. Little or nothing is left in the blackband seams, but a considerable area of the Johnstone Clayband is still intact around Abbotsinch and in the trough west of Inchinnan.

*The Johnstone Clayband Ironstone,** being the lowest seam of the series, covers the most ground: it is a continuous bed with a remarkably uniform thickness of about 1 foot, and is the only workable clayband ironstone in the sequence.

Between Inkerman, west of Paisley, and Newfield, north-west of Johnstone, the old workings in this seam are practically continuous, and nearly 3 sq. miles of the ironstone must have been taken out in this area. In the Clippens, Milliken and Newfield Pits operations were carried on right up to the outcrop: eastwards the workings slowly deepened until, under the Linclive basin, they reached a depth of upwards of 150 fms. This ironstone extends beneath a large part of Johnstone as far south as the 50-fm. upthrow fault in the centre of the town. Apart from the old Cartside Pit, close to the railway junction, no workings were carried on south of the Black Cart in this area. The section in the Barbush Pits may be taken as a good average for this part of the district; it was as follows:—

	Ft.	In.
CLAYBAND IRONSTONE roof	0	3
Blaes	1	3
CLAYBAND	0	2
Blaes	2	0
JOHNSTONE CLAYBAND	1	2
Blaes pavement		

There is also a well-defined little basin of this Ironstone near Waterstone, between Bridge of Weir and Johnstone. The whole of this area has been practically wrought out from shallow pits and day-levels: two of the latter at the stream level immediately above the railway viaduct are still open.

At the Abercorn Pits, further to the east in the Linclive basin, the section was much the same as that found at Johnstone: namely—

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* Sometimes known as the Linwood Clayband.

	Ft.	In.
Blaes	1	0
CLAYBAND IRONSTONE	0	6
Blaes	2	5
JOHNSTONE CLAYBAND	1	0
Blaes		

Very little has been done on the left bank of the Black Cart, north of Middleton, and here 100 acres or more of the seam should remain still untouched. The Ironstone dips S.E. from the outcrop but is cut off to the north by a 40-fm. downthrow fault. We have no information as to the condition of the seam in this area: the nearest bore—by the riverside at Middleton—proved the Ironstone, 16 in. thick, at 61 fms.

The dip of the beds is reversed further to the east, and a series of old bores show that the Ironstone comes to the surface under Paisley Racecourse. North of the 40-fm. fault near Boghead extensive operations have been carried on from the Blackstone and Walkinshaw Pits: the ground here is much "troubled" and broken up by faults; two of these, under Blackstone Works, have throws of 23 and 36 fms. to east and south respectively, the latter increasing to perhaps as much as 60 fms. in an easterly direction. These workings were all abandoned before the year 1902 with the exception of Nos. 2 and 3 Pits, Walkinshaw, which were wrought until 1914. The general section here was:—

	Ft.	In.
Blaes roof		
CLAYBAND IRONSTONE	0	6
Blaes	1	4
CLAYBAND IRONSTONE	0	5
Blaes	0	9
MAIN (JOHNSTONE) CLAYBAND	1	2
Blaes		

Both the top and bottom ironstones were worked, but the 5-in. rib above the main seam proved to be useless; it was crowded with small, yellowish, irony concretions, apparently of oolitic origin. Along the northern margin of the Walkinshaw field a "whin" dyke was encountered which burnt the strata on either side: this intrusion is probably the same as that seen in the farm-steading at Barnhill, east of Houston Station, where it contains abundant included fragments of dark blaes. These workings were finally cut off to the north by a 45-fm. upthrow fault at Wester Yonderton. By this dislocation the ironstone is thrown out altogether but comes on again towards Inchinnan in a well-marked syncline. There must still be at least three quarters of a square mile of untouched ground here; the only workings were on a very small scale and near the deepest part of the basin south of Bottom, where was a pit 44 fms. in depth; a bore close to this pit proved—clayband, 9 in.; blaes, 2 ft. 9 in.; clayband, 13 in.

A similar record was got in another boring south of Greenhead, where the section was:—

	Ft.	In.
Blaes		
CLAYBAND IRONSTONE	0	6
Fakes and blaes	6	2
CLAYBAND IRONSTONE	0	8
Fakes and blaes	2	10
JOHNSTONE CLAYBAND IRONSTONE	1	2
Fakes and blaes		

The main seam in this bore was struck at 14½ fms.

Another almost untouched field of the Ironstone is available north of Barnhill: it is let down between two large faults, which at Barnhill are about a mile apart, but approach one another in a northerly direction and almost meet before they are cut off by the powerful east-and-west upthrow at South Barr. A trial was made in this area close to the smithy at Wardhouse, where an acre or two was worked from a mine driven through the eastern 70-fm. fault from workings in the Hurlet Coal.

The section here was—clayband ironstone 6 in.; blaes, variable, clayband ironstone 1 ft.

An important "mussel-band" is met with 10 to 15 fms. above the Johnstone Ironstone which may be conveniently termed the *Johnstone Shell-bed.* No surface exposures of this bed are known in this area, and the best section observed in recent years lies somewhat outside this district,—at the Pollok Pit at Corkerhill, half-way between Paisley and Glasgow. In sinking this pit to the Johnstone Clayband in 1905, the Shell-bed was found as a dark limy blaes, crowded with *Lingula* in the upper part and with an equal profusion of marine forms—chiefly small Producti and a "horn coral" (*Zaphrentis* cf. *enniskilleni*) — immediately below.

From specimens collected many years ago by the Survey at the Inkerman Pits near Linwood, it would seem that this horizon presents much the same character in the Paisley-Johnstone district as at Corkerhill. It no doubt underlies the whole region, since it is known to have a very wide distribution along the south side of the main Lanarkshire coalfield. This Shell-bed is easily missed in chisel bores; occasionally some harder band in the shelly blaes has been noticed, as in a bore near the old pit west of Portnauld—"a hard rib of shells." Sometimes again the whole position is recorded: thus the journal of No. 3 bore, Blackstone—at the side of the river Cart Middleton—gives it as follows:—

	Ft.	In.
Mussel IRONSTONE	0	2½
Dark blaes with shells	2	4
IRONSTONE	0	1½
Dark blaes with shells	0	11½
IRONSTONE	0	4
Dark blaes with shells	4	3

The same horizon has been proved in No. 1 bore, Barbush, north of Johnstone. Little attention seems to have been paid to the Shell-bed by miners, although it would prove an excellent index-mark when boring to the Johnstone Clayband, 10 to 15 fms. below, especially when cores can be obtained for examination: it is the only strongly-marked "mussel-band" in the Limestone Coal Group; that found in the "Logan's Bands" or "Black Metals" being in this area much less striking in character.

The Lower Blackband—the equivalent of the Govan and Lower Garscadden Ironstones—was in great request 30 or 40 years ago. As this seam lies 40 fms. or more above the Johnstone Clayband the area covered by it is of less extent. The workings were carried right up to the outcrop and the ironstone completely wrought out. Compared with other seams of the same class, it was unusually regular in its occurrence, with less tendency to pass laterally into a coal: the average thickness was 1 foot.

Round Linwood the Lower Blackband occupied a well-marked basin, truncated on the south-east by the "Paisley Ruck." The general inclination of the beds was somewhat high—frequently as much as 1 in 3—so that the seam lay at a depth of over 110 fms. in the Abercorn Pits in the centre of the basin. There were few faults in this small field, the two principal dislocations had each a downthrow of 8 fms. to the south, passing respectively through Linclive and Candren: a smaller basin lies to the north, at Boghead.

In the area round Blackstone House and Wester Walkinshaw the Blackband Ironstone is let down between two large faults with downthrows of 30 to 40 fms. The outcrop along the Black Cart is repeated by further faulting, bringing down a small area under Blackstone House. The whole of this ground has been wrought out; east of Wester Walkinshaw the ironstone was 15 in. thick, but north of Mosside, where the workings were stopped, had dwindled to 6 in.

Further to the north the seam does not "take on" for about 2 miles; it then reappears N.W. of Renfrew where it is thrown in by the great Blythswood Fault, which has a downthrow to south of 100 to 200 fms. The outcrop of the Blackband lies between Bottom and Portnauld, where it was entirely wrought out from shallow pits. On the east side of the Black Cart the seam lay deeper, with a steady dip to S.E.: the chief pit here, 81 fms. in depth, was situated in the grounds of Blythswood House, 400 yds. west of the station. No great amount of ironstone was raised here, the field being restricted by the Blythswood Fault and a branch dislocation to the south. The Blackband was occasionally 17 in. or more in thickness but proved to be more irregular than usual.

The Upper Blackband Ironstone as a workable subject was entirely local, occurring over most of the district only as a thin coal position. It was mined to some extent near South Candren, but elsewhere seems to have attracted no attention.

Logan's Bands—the equivalent of the ironstones in the "Black Metals" of Kilsyth, the "California Claybands" of Knightswood and the "Maggie Bands" of Carluke—are of no economic value in the Paisley district. The position—a thick mass of dark blaes with numerous ribs and balls of clayband ironstone—is very constant, but none of the bands proved workable. Over the greater part of the Central Coalfield a band containing marine fossils occurs with these strata, but in the absence of surface exposures nothing can be said as to its presence in this region.

The Possil Coals have an extremely limited distribution in the Paisley district. They have only been wrought in the small basin at Linclive, where the workings were not carried south of the 8-fm. downthrow that crosses the centre of the basin: in the bores put down beyond this fault, east and south-east of Linclive, all the coals were found to be too thin for profitable working.

Six seams were wrought from No. 2 Pit, Abercorn (see Plate VIII., Section 2). They lay at a high angle, dipping south at 1 in 3. Average sections of these seams, as recorded on the colliery plans, are given below.

		Ft.	In.
ROUGH COAL	Rock roof		
	Blaes	0	3
	COAL	2	4
	Rock pavement		
STONY COAL	Blaes	1	4
	COAL	0	9
	Blaes and dirt	1	11
	COAL	2	0
	Daugh and fakes		
MAIN COAL	Blaes	2	6
	COAL	1	0
	Parting	0	4
	COAL	1	2
	Daugh and rock		
SPLINT COAL	Blaes	2	1
	COAL	2	3
	"Mussel"	0	2
	Blaes		
STEAM OR SOFT COAL	Sandstone roof		
	Blaes	1	0
	COAL	1	3
	Dirt	0	4
	COAL	1	3
	Bastard fireclay		
TURF OR BORESTONE COAL	Blaes	2	6
	Daugh	0	6
	COAL, splint	0	6
	COAL, free	1	5
	Fakes		

Most of the workings were in the Steam or Soft Coal, and to a less degree in the Main Coal; little attention was paid to the other seams, which were probably of poor quality. Now that thin coals under modern mining conditions are more in demand, the advisability of a further trial of the Abercorn seams on the south side of the 8-fm. fault which marked the limit of the original workings may be suggested. The position of the lowest—the Turf Coal—should not be more than 60 fms. from surface, and all the coals rise to the crop towards the south-west. An interesting feature in the Linclive basin is the appearance of the *Index Limestone,* which just "takes on" in the centre of the syncline: with the exception of a still smaller outcrop of this limestone at Blythswood, this is the only part of the Paisley district in which strata so high in the sequence are found. In No. 1 Bore, Linclive (1859), the Index was proved, 4 ft. 9 in. thick, in a position 23 fms. above the Rough Coal.

A small area of the Possil Coals, or at least of the lower seams, appears to be present in the trough S.E. of Boghead. In a bore whose situation is given as "in the field opposite the road into Boghead" a 3-ft. seam of "soft coal" was got at 17 fms.: this is probably the Turf Coal of Abercorn, for the bore further proved the Lower Blackband 46 fms. below—a total depth of 63 fms. Another bore "in the field opposite offices"—which stood by the roadside at East Candren—proved 20 in. of "soft coal" at 15 fms., with another seam foul coal, 8 in., soft and hard coal, good, 17 in., at 17½ fms., the latter possibly representing the Turf Coal. None of those coals appears to have been worked, and although they cover but a small area they might be worth investigation in view of their small depth below surface.

A curious little strip of these coals is let down between two large faults south of Middle Walkinshaw. They were proved in a stone mine driven to reach the Lillie's Shale Coal on the north. Four seams were passed through, all steeply inclined; of these the highest in position was the best; it was identified with the Stony Coal and showed 13 in. top coal, 10 in. stone, and 12 in. bottom coal.

The only other known outcrop of the Possil Coals in the district lies on the north-west side of Renfrew, south of the Blythswood Fault. At least 8 seams were met with here in boring for the Lower

Blackband Ironstone. They were mostly recorded as "foul coal" and never wrought. One of the seams was 32 in. in thickness, and may perhaps be identified with the Main Coal of Abercorn. The Splint measured 21 in., and another, about the position of the Turf Coal, was described as 20½ in. of "clean coal." This seam was again proved at 70 fms. in a bore on the west side of the railway station, where it is recorded as 4 ft. 5 in. thick, but the ground is much faulted and this figure is probably excessive. There was a good deal of gas coal in this seam, which is no doubt the equivalent of the Gas Coal of Knightswood, the lowest of the Possil Seams in the Glasgow district. The bore-journal reads as follows:—

	Ft.	In.
Roof—blaes with ironstone rib		
RADICAL or coarse GAS COAL . .	1	10
SOFT COAL	0	3
GAS COAL	1	10
SOFT COAL	0	6
Pavement—daugh and fakes		

Since most of these coals must have been passed through in sinking No. 4 Pit, Blythswood, to the Lower Blackband, and no workings in them were ever undertaken, it may be inferred that they are of inferior quality.

THE "PAISLEY RUCK."

None of the dislocations that affect the Paisley district calls for any detailed notice with the exception of the remarkable crush-line, termed in this Memoir the "Paisley Ruck." Although a leading tectonic feature of the region, it does not appear to have been hitherto referred to or described.

The line of disturbance begins on the north side of the Clyde near Drumchapel, whence it can be traced in a south-west direction across the river, past the north side of Paisley, by Johnstone and on through the Lochwinnoch gap into North Ayrshire, where it appears to break up.

As a general rule the Ruck takes the form of a crush-zone or shatter-belt, 150 to 200 yds. in breadth, within which the strata are highly inclined or broken in all directions. The edges are sharply defined, usually by a fault of some kind, but the displacement on either side varies greatly in amount. It reaches a maximum near Linwood, where the Index Limestone on the north side of the Ruck lies opposite sandstones below the Castlehead Coals on the south,—a displacement of more than 300 fms.

This amount of throw is quite exceptional and soon diminishes: to the north of Paisley the dislocation is reduced to 33 fms. and to less than 15 fms. at Quarrelton.

The anticlinal phase of the Ruck is well seen at its northern extremity, where it is described in "The Geology of the Glasgow District"* as follows: "at Blairdardie . . . an abrupt anticlinal fold, with a N.E.-S.W. axis, is found east of the canal and was proved in a stone mine driven from the old Blairdardie Pit. For the details of the section given below (Fig. 3) we are indebted to Messrs. Wm. Dixon Ltd.

* *Mem. Geol. Surv.*, 1911, p. 161.

The eastern limb of the fold was met with in the Cowdenhill Pits, where the Main Coal was inclined to the south-east at 45°."

The Ruck is next encountered south of the Clyde at Porterfield, south of Renfrew. A pit sunk long ago 50 yds. east of the railway in search of the Hurlet Coal met with "strange metals," while a bore at the Clyde Rubber Works close by, in 1904, passed through 109 fms. of strata, whose record is quite undecipherable: in the original journal of the bore the remark is made "we are straight down a fault or dyke."

Still better evidence was obtained in this neighbourhood from a diamond bore sunk in 1913 at Messrs. Tennant's Works, where the rock-head was reached at a depth of 13 fms. 4 ft. from surface and cores were obtained down to 70 fms. The strata throughout were found to be on edge and twisted and shattered in an extraordinary manner; the sequence, consequently, could not be made out and it was evident that an ordinary fault was not in question.

The workings of the Caledonia Fireclay Pit, a mile to the S.W., have supplied some interesting data. Between the years 1902 and 1905 an attempt was made to reach the Hurlet Coal, which was known to lie at a depth of about 70 fms. under Paisley Racecourse (St. James's Park). The fireclay workings on the south side of the Park had been stopped at a fault-face through which a stone mine was driven. Instead of meeting the coal almost immediately as expected, the mine entered a belt of shattered and upturned rock nearly 200 yds. in breadth (see Plate VI.). The work was naturally both difficult and dangerous, and at one spot a serious explosion was caused by gas issuing from a 6-ft. block of loose coal, embedded in limestone and fireclay fragments. The operation was nevertheless persisted in until "clean" strata were suddenly entered, and the mine was carried on till workable seams of fireclay were met with. Incidentally it may be mentioned that above the fireclays was a 10-ft. limestone, resting on a 1-ft. coal: these were believed to represent the Hurlet Seam. The levels taken just before the workings were abandoned show, however, that the limestone was in the position of the Blackbyre Seam, and had the mine been inclined slightly upwards instead of downwards the Hurlet Coal, nearly 4 ft. thick, would have been struck (see Plate VI.). The Paisley Ruck was next touched in a trial shaft for ironstone, sunk by the lodge-gate at Kebbuckston, on the west side of Paisley. From this point it passes N.W. of Barskiven Hill and N. of Elderslie, where it throws off the Hurlet Limestone

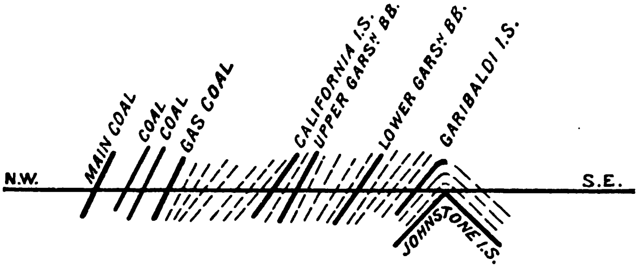

FIG. 3.—Section of Stone Mine in Blairdardie Pit.

and Coal dipping N.W. at 1 in 1, as proved in an old working. A part of the crush-zone can be seen in the railway-cutting east of Johnstone High Station, where smashed and fragmentary coal, sandstone and fireclay are pierced by a couple of dolerite dykes. South-west of this point the zone is crossed by the Craigbog Burn, near the Linn House, where a narrow strip of the Clyde Plateau lavas is brought up, inclined at a high angle.

To the north and south of Quarrelton it is known to interrupt the continuity of the Thick Coal, and in the stream below Corseford Mill ashy detritus beneath the Hurlet position is brought up, dipping at an angle of 35°. Further to the west the "Ruck" crosses the Black Cart between Warbowie and Thirdpart Hall, where a belt of shattered and upturned limestone and blaes, 125 yds. in breadth, can be seen in the river-banks. Similarly, in the cores of a bore, put down in 1912 between the river and the Glasgow and South-Western Railway at Corseford, fragments of ashy detritus and coal were found mingled with the limestone debris.

The continuation of this great zone of disturbance through the Lochwinnoch gap into Ayrshire has not yet been definitely traced, but it is known that the small coalfield at the south end of that loch is truncated by large faults which affect the strata at least as far south as Kilbirnie. The long valley above Kilbirnie is directly in line with the direction of the Ruck in Renfrewshire and this alignment is suggestive of an extension of the shatter-belt into Ayrshire.

The Paisley Ruck was no doubt produced by the same earth-movements which gave rise to the well-known anticlinal fold known as the "Riggin," at Kilsyth, and to the sharp monoclinal fold in the Hurlet field; the axes of both of these trend in a similar N.E.-S.W. direction.

R. G. C.

CHAPTER IV.

GLASGOW DISTRICT—(*a*) SOUTH OF THE CLYDE.

Renfrew, 8 S.E.; 12 N.E., S.E.; 13 N.W., S.W.; 16 N.E.; 17 N.W.; Lanark, 5 N.E., S.E.; 6 S.W.; 10 N.W.

CARBONIFEROUS LIMESTONE SERIES.

(See Plate VII.)

THIS district includes all the area south of the Clyde to the east of Paisley and south-west of Glasgow City, in which rocks of this Series are present either at the surface or concealed by higher members of the Carboniferous sequence. In the southern part of the district the strata dip from all sides towards an elongated centre of depression, forming the structure known as the Arden Basin. The diagram (Fig. 4) below gives a horizontal section across this basin from north to south.

LOWER LIMESTONE GROUP.

Hurlet Limestone and Coal.—Surface exposures of the Hurlet Seam in this part of the district are practically non-existent. The limestone can, however, be seen at Hurlet, at the mouth of an old mine inside the wood about 400 yds. south of West Hurlet House.

In the area immediately to the east of Paisley a sill of teschenitic dolerite has been intruded along the horizon of the Hurlet Seam and a good section showing the relation of the sedimentary and igneous rocks is exposed in the cutting near Arkleston Junction on the Glasgow and Paisley Joint Railway.

The limestone, with a maximum thickness of 3½ ft., lies at the top of the section, and is underlain by 6 in. of alum shale, much burnt and pyritised; followed by the dolerite sill and the Hurlet Coal. The latter—originally from 5 to 6 ft. thick—has been split up the centre by the intrusive rock, and now lies in part above and in part below the dolerite, which is here about 80 ft. in thickness. The coal is much burnt and shows fine columnar structure. Beneath the coal follow 18 ft. of blaes and fireclay with a band of entomostracan limestone in three seams, and much pyritised.

A complete section of the seam was exposed some years ago during the building of the Renfrewshire Poorhouses at Old Crookston, about a mile N.N.E. of Hurlet. This section is no longer visible: a full description, from observations made at the time, was, however, given in "The Geology of the Glasgow District" (*Mem. Geol. Surv.*), and may be repeated here.

"The strata were inclined gently to the south-east. The highest beds consisted of dark blaes, unfossiliferous but containing numerous small balls of clayband ironstone. Underneath came the Hurlet Limestone, from 2 to 3 ft. in thickness, dark grey in colour, and almost wholly composed of broken fragments of small encrinite stems. Specks of pyrites occurred towards the base of the limestone, and the lowest part of the seam was distinctly marmorised by the underlying dolerite. The alum shale was only 1 or 2 in. thick, and had been much hardened by contact alteration, the thin shaly partings being covered with a pyritous glaze. The underlying dolerite sill varied from 10 to 15 ft. in thickness, and throughout contained lumps of coal burnt to a coke ("grey maggie"), and showing good columnar structure. Although the igneous rock had been converted into a "white trap" there was no evidence of absorption of any part of the surrounding strata. Some fireclay occasionally occurred under the coal, but in most places this was absent, and the coal rested directly on dark blue blaes. Close underneath was a dark entomostracan limestone, in thin beds, passing downwards into a light-coloured grey cement limestone. A section at the S.W. corner of the Children's Block gave:"—

	Ft.	In.
Boulder clay	2	6
White trap, with lenticles of coal at base .	3	6
Dark blue blaes	1	0
Lenticle of dark entomostracan LIMESTONE with fish remains . . .	0	2
Dark blue blaes	0	6
Gray cement LIMESTONE, lighter-coloured towards the base, with rootlets and coprolites	0	8 seen.

R. G. C.

The dolerite sill found in this section does not persist very far either to the east or south, and the Hurlet Coal was worked from various old pits which extend parallel to the strike on either side of the village of Hurlet. The northern limit of the workings was formed by an extension of the Newton Fault (see p. 5), which runs past Hawkhead Asylum, and intercepts the Lower Limestones not far to the south of Byres. The seam was also worked to the dip from the old Freetrader Pit, and, very extensively, from the present Victoria Pits, Nitshill. The Coal was here reached in the shaft at a depth of 175 fms., and the workings, which extended both to south-west and north-east, were carried (at at least one point) to a depth of over 250 fms. An explosion in the

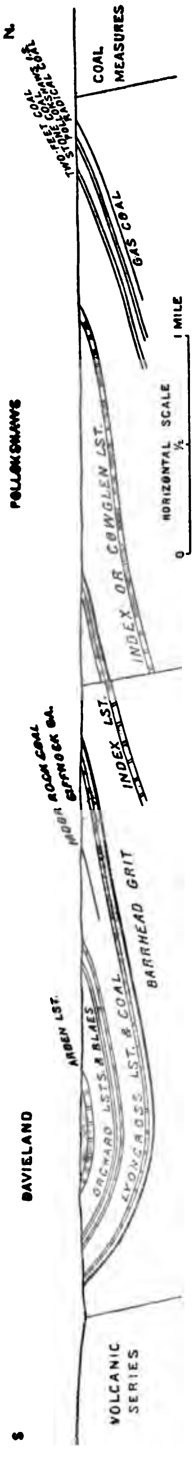

FIG. 4.—Horizontal Section across the Arden Basin from near Holm to Pollokshields.

year 1851 caused the loss of sixty-one lives, and the workings were abandoned at a subsequent date. M'Phail states that the coal averaged 5½ ft. in thickness, and adds:* "There is found at intervals, lying above the coal in this pit, a blackband ironstone, varying from 3 to 6 in., locally known as 'panel,' which yields about 33 per cent. of pure metallic iron. Above it is the alum shale, varying from 1 in. to 7 ft. in thickness, succeeded by the well-known Hurlet and Campsie Limestone, varying from 2 ft. to 3½ ft. in thickness. Over the limestone there are 5 ft. of clay shale, which yields a large supply of alum by the 'sulphuric acid' process." An analysis of the alum shale is quoted by Dron.† It was treated at alum works close to the pit.

The coal in this district has its usual pyritous character, and this was probably one reason why these deep workings were abandoned. The shallower areas have probably been exhausted in this district, except to the north of the Newton Fault. It is there again, however, much burnt by the dolerite. The latter was 9 fms. thick in a bore near South Cardonald, and extends at least to the Clyde. There is thus little chance that workable coal will be found on this horizon between Arkleston and Govan.

There is, however, an interesting record from a bore put down from the old Titwood Colliery, a little to the south of the Maxwell Park (see Plate VII., Fig. 6). Here the section was:—

	Ft.	In.
Sandy LIMESTONE	1	10
Aluminous schistus	2	4
COAL	5	9
Fakes	0	3

The depth from the surface was 213 fms., and the coal is not stated to be burnt, nor is there any mention in the journal of intrusive dolerite. Assuming this record to be correct, it may be taken as showing that large areas of reserve occur at considerable depths in the eastern part of the district at present under discussion. The depth of the Hurlet Coal beneath the Index Limestone is about 260 fms.

The diagram below (Fig. 5) shows the depth *from the surface* at which the Coal would most probably be met over most of the Barrhead and Giffnock area. It also shows, very roughly, the amount exhausted, as well as the probable extent of burning by the sill referred to. As the surface is not very hilly, the lines of equal depth are approximately level-courses. Some doubt may exist as to the condition of the Coal in the south-eastern corner of the ground represented, as it fails entirely at Thorntonhall, 2 miles further to the south and east.

E. M. A.

Part of the thick mass of blaes that lies between the Hurlet and Blackhall Limestones is exposed along the Levern Water north-east of Hurlet. The numerous bands and nodular layers of clayband ironstone in this blaes are often slightly calcareous, and north of the Clyde near

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* "On the Carboniferous Sections of the Levern Valley, Renfrewshire," *Trans. Geol. Soc. Glasgow*, vol. iii., 1871, p. 254.

† "The Coalfields of Scotland," 1902, p. 88.

Bearsden seem to have passed into thin limestones. The ironstone ribs are thicker and more abundant in the upper part of the blaes, and two of the principal horizons have been distinguished respectively as the Upper and Lower Househill Claybands; the former lies

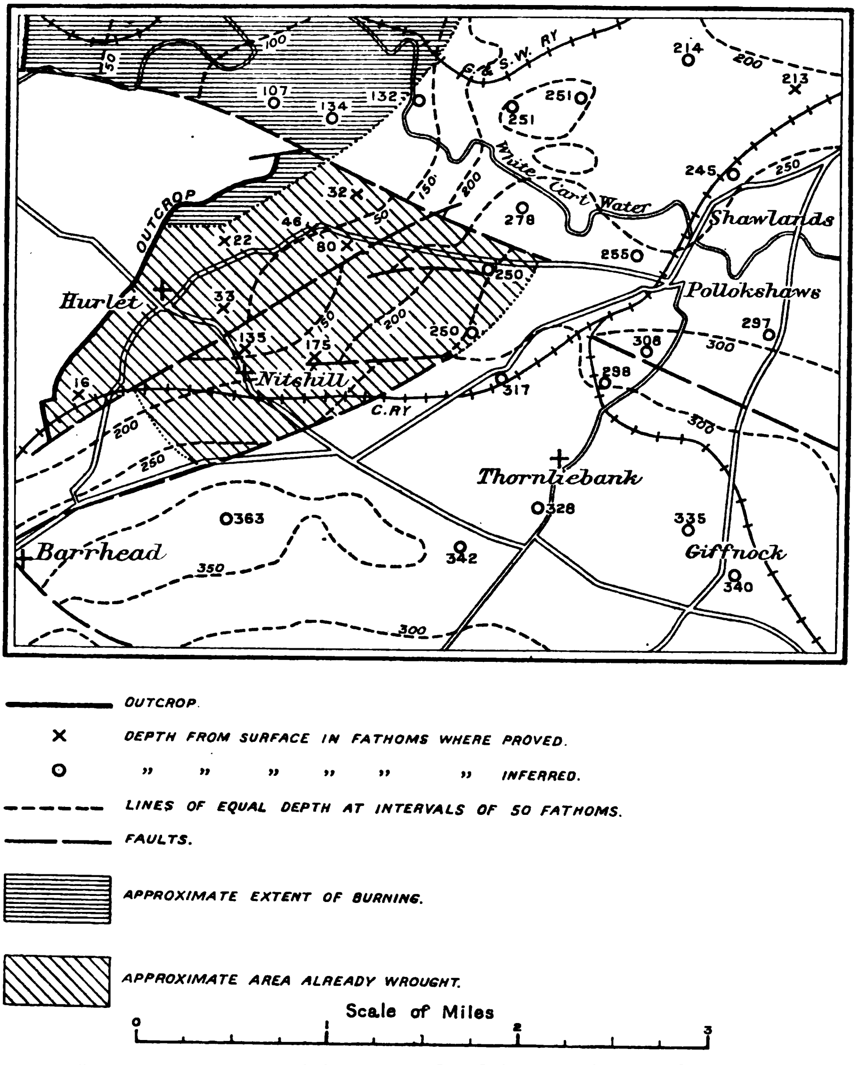

FIG. 5.—Sketch Map of the Barrhead and Giffnock district, showing area and depth from surface of Hurlet Coal.

approximately 8 to 15 ft. below the Blackhall Limestone, the latter some 4 to 6 fms. lower in the sequence.

The Househill Claybands are typically developed in the Hurlet-Nitshill district south of the Clyde. They were formerly worked from several pits along the Levern Water to the east of Hurlet, and are still (1918) raised at Messrs. Baird's Victoria Pits at Nitshill Station.

The section of the Lower Clayband working, 8 fms. below the Blackhall Limestone, in the Victoria Pit, shows:—

	Ft.	In.
Blaes with clayband ironstone ribs		
CLAYBAND	0	6
Blaes	4	6
CLAYBAND	0	3
Blaes	2	6
CLAYBAND	10 in. to 0	12

The section of the Upper Clayband in the pit shaft is as follows:—

	Ft.	In.
CLAYBAND	0	10
Blaes	1	11
CLAYBAND	0	9
Blaes	6	4
CLAYBAND	0	10

its position being approximately 15 ft. beneath the Blackhall Limestone.

The complete section in the old Turnberry No. 1 Pit was:—

		Ft.	In.
	BLACKHALL LIMESTONE		
	Blaes and ironstone ribs	10	10
Upper	CLAYBAND	0	5½
	Blaes	5	7
	CLAYBAND	1	2
	Blaes and ironstone ribs	29	8
Lower	CLAYBAND	0	9
	Blaes	5	5½
	CLAYBAND	1	2

There is little doubt that the Househill Claybands will be found of workable thickness over a considerable area south and east of the Victoria Pits, but the dip of the strata being to the south, and the Lower Clayband lying 150 fms. from surface in the existing shaft, the question of depth becomes of importance. Difficulties of working due to faults, and the presence of water in the old Hurlet Coal workings to the north-east of Nitshill, have also to be reckoned with.

The record of bores near Crookston Castle and Hillington show that these Ironstones occur also in workable thickness in the ground north of Nitshill.

The Househill Claybands worked at Messrs. Baird's pit at Corkerhill lay 3½ fms. below the Blackhall Limestone, in the position of the higher ironstone horizon proved in each of these bores. This pit suspended operations in 1914, but may be re-opened. Both the Johnstone and Househill Claybands were raised here, but proved costly to work on account of faults.

Little is known as to the development of the Househill Claybands in the ground east of Corkerhill. In the deep Titwood bore at Maxwell Park Station numerous ironstone ribs, from 2 to 8 in. in thickness, were met with in the blaes beneath the Blackhall Limestone, which here lies at a depth of 170 fms. from surface (see Plate VII., Fig. 6).

The *Blackhall Limestone* is exposed at the old limekiln, between the Levern Water and the main road, 500 yds. north-east of the cross-roads in Hurlet village. It is also seen by the side of the White Cart, south-west of Ross Hall Mains, and in an old quarry, south of the river, about half a mile east of the name locality of Blackhall.* The section is in each case somewhat similar to that exposed in the Gryfe Water (see p. 35), though the green marl and entomostracan limestone differ in thickness, and very little is seen of the Neilson Shell-bed.

The *Main Hosie Limestone* and underlying Hosie Sandstone are seen in the Levern Water at the Cross Arthurlie Street Bridge, in Barrhead. The Main Hosie is here a massive encrinital limestone, as in the bores and pit shaft at Corkerhill. A thin oil shale, seen a short distance above the limestone in this section, may represent the *Lillie's Coal and Oil Shale*, which follows a few fathoms above the Main Hosie Limestone. This seam varies greatly in character: in an old pit south-west of North Hillington it was found as an oil shale 3 ft. in thickness, while in a bore a quarter of a mile to the east it was represented by two seams of coal separated by 28 ft. of sandstone (see also Plate VII., Fig. 6). It also occurs as a foul coal at Hurlet. A full description of this seam, as met with in the adjoining Paisley District, is given on p. 37.

The *Top Hosie Limestone* does not appear to be exposed in natural section within this district. Specimens of the limestone, identical in character with the Calderwood Cement of East Kilbride, were, however, obtained during the sinking of the ironstone pit at Corkerhill. R. G. C.

LIMESTONE COAL GROUP.

Along the axis of the Arden Basin the rocks of this Group are in places overlain by more than 100 fms. of Upper Limestone strata, but they rise to the surface and occupy an irregular area to the north. Mining has taken place in different localities, both for coal and for ironstone, but the relative thinness of the coals has delayed their active development. At the time of writing one coal and one ironstone pit are in actual operation.

It is impossible, by means of a single vertical section, to represent accurately the condition of the minerals over the area as a whole. In the table which follows the upper part of the sequence is taken from an old pit at Cowglen, while various records have been averaged for the part which underlies the Quarry Coal.

General Section of Limestone Coal Group. District of Govan, Barrhead and Giffnock.

	Thickness.			Depth.		
	Fms.	Ft.	In.	Fms.	Ft.	In.
INDEX OR COWGLEN LIMESTONE						
Strata	30	0	0	30	0	0
SCLUTTY COAL	0	3	4	30	3	4
Strata	2	5	4	33	2	8
SMITHY COAL	0	1	6	33	4	2
Strata	1	5	0	35	3	2

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* John Smith, *Trans. Geol. Soc. Glasgow*, vol. xii., 1902, p. 64.

	Thickness Fms.	Thickness Ft.	Thickness In.	Depth. Fms.	Depth. Ft.	Depth. In.
Rough Coal	0	2	8	35	5	10
Strata	0	5	5	36	5	3
Stinking Coal	0	1	9	37	1	0
Strata	2	1	8	39	2	8
Geordie's Coal	0	1	4	39	4	0
Strata	4	4	0	44	2	0
Quarry Coal	0	1	0	44	3	0
Strata	4	2	0	48	5	0
First Ironstone Coal and Ironstone	0	1	0	49	0	0
Strata	1	4	6	50	4	6
Two-feet Coal	0	1	6	51	0	0
Strata	2	0	6	53	0	6
Stone Coal { Coal	0	0	10	53	1	4
Stone Coal { Blaes	0	0	10	53	2	2
Stone Coal { Coal	0	0	10	53	3	0
Strata	7	1	6	60	4	6
Second or Pollokshaws Ironstone and Coal	0	1	6	61	0	0
Strata	1	4	0	62	4	0
Radical Coal	0	2	0	63	0	0
Strata	4	4	0	67	4	0
Titwood Gas Coal	0	2	0	68	0	0
Strata	31	5	0	99	5	0
Ibrox or Govan Blackband Ironstone	0	1	0	100	0	0
Strata	49	5	0	149	5	0
Johnstone Clayband Ironstone	0	1	0	150	0	0
Strata	16	0	0	166	0	0
Top Hosie Limestone						

The lowest part of the Limestone Coal Group consists usually, in this district as elsewhere, of a thick mass of blaes extending upwards to a few fathoms above the Johnstone Clayband.

Johnstone Clayband Ironstone.—This seam, which is taken off by faulting in the vicinity of Paisley, is brought on again by the dip of the metals some distance to the east. It was worked in an old pit near North Hillington, on the south side of the Glasgow and Paisley railway, and from another a little west of Cardonald Junction on the same side of the line. The sections were as follows:—

Cardonald.	Ft.	In.
Coarse clayband		
Blaes	3	0
Blaes brushed	1	0
Clayband 6 in. to	0	8
Blaes	3	6
Clayband	0	11
Blaes pavement		

Hillington	Ft.	In.
Blaes		
Clayband	0	10
Blaes	2	6
Clayband	1	0
Blaes pavement		

It was also worked, at a depth of 68 fms., in a pit near Mid Drumoyne, some distance to the south of the Elder Park, where its thickness is recorded as 14 in. Between this point and its outcrop there is probably a fairly large area of unworked ironstone, which extends to the north of the Cardonald and Hillington workings referred to. An old bore near the Govan Combination Poorhouse gave the following section at a depth of 38 fms.:—

	Ft.	In.
CLAYBAND	0	8
Parting	0	1
CLAYBAND	0	4
Dark blaes	3	3
CLAYBAND	1	1
Blaes	0	2
CLAYBAND	0	5

A trial pit was sunk near this locality in the year 1868; it is not known why mining was not proceeded with, but the pit appears to have been on the line of a 30-fm. fault. Two other bores to the south-west found the Clayband at less than 50 fms., with a section similar to the one just quoted; in one case, however, the two highest bands are quoted as irony fakes instead of ironstone. Sinking in this neighbourhood might, however, in places be hindered by the presence, at the surface, of an unusual thickness of loose superficial deposits (see p. 96).

The seam is probably taken off by a W.N.W. fault, somewhat to the south of South Cardonald, but it crops, and was formerly worked opencast, near Crookston Station. South-east of this point it is thrown out by a smaller fault, but soon comes on again, as it underlies the grounds of Crookston Castle, and was worked quite recently at the Pollok Pit, not far from Corkerhill.

Some distance to the south another large fault, running W.N.W. and forming a continuation of the Newton Fault (see p. 5), would probably be encountered. There is, however, a further workable area near Nitshill, where the seam is at present being raised at the Victoria Pits from a depth of 80 fms. The section is:—

	Ft.	In.
CLAYBAND	0	8
Blaes	4	6
CLAYBAND	1	0

The seam increases in depth, and has only once been reached by boring to the east of the two localities last noted. This bore was at the old Titwood Colliery, south of the Maxwell Park, where the depth to the Johnstone Clayband was about 100 fms., and the section, as far as it is likely to have been accurately ascertained, as follows (see Plate VII., Fig. 6):—

	Ft.	In.
CLAYBAND	0	2
Blaes	2	4
CLAYBAND (with lime)	1	3

This record possibly indicates that a large area of the mineral may remain intact between Bellahouston and Pollokshaws, though the extension of the city in this direction would no doubt hinder its development. How far the Ironstone extends to the south and east of Nitshill is largely a matter of conjecture, though in view of its general persistence it would not be surprising if it underlay a considerable part of the Arden Basin.

The presence of the Johnstone Shell-bed at Corkerhill has been referred to in a previous section.

A coal, 13 in. thick and 32 fms. above the Johnstone Clayband

Ironstone was worked to a small extent at Cardonald, under the name of the Gas Coal, but it may quite possibly be the equivalent of the Kilsyth Coking Coal. There are two thin coals, however, in neighbouring bores, at distances of 7 and 11 fms. respectively below the Lower Garscadden Blackband, and it is uncertain to which of the two the worked coal may correspond. The probable equivalents of the same two coals were found in the shaft of the old Freetrader Pit, north of Nitshill, where the upper had a thickness of 20 and the lower of 14 in., while a 10-in. coal in the Titwood bore is probably on one of these two horizons. As thin coals occur, to the north of the Clyde, both above and below the Kilsyth position, it would not be safe to attempt a closer correlation, but the two coals under discussion are undoubtedly members of what may be termed the Kilsyth Group. It is not known whether they have coking qualities.

Garibaldi Clayband Ironstone.—Two bands of clay ironstone, in the position of the Garibaldi seam, were formerly worked at a distance of 3 fms. below the Lower Garscadden Blackband, in two old pits, sunk probably in the first place for the latter, and situated close to Govan. The bands were respectively 4 and 6 in. in thickness, and separated by 2 or 3 ft. of blaes.

Lower Garscadden, Govan or Ibrox Blackband Ironstone.—In contrast with the Johnstone Clayband, this seam varies rapidly throughout the district, being often replaced by a thin coal, and there is not much ground in which it is likely to be workable, except round the shafts where it has actually been wrought.

The Ironstone is thrown out to the south of the Blythswood workings (see p. 43) by a large fault, and where it appears again near Cardonald, as far as it has been proved, measures only from 2½ to 5 in. in thickness. Eastwards, however, it rapidly improves, and was extensively wrought from numerous small pits in the neighbourhood of Govan and Ibrox, where the seam varies from 10 to 19 in. in thickness. There appears to be no record that it has been worked to the south of the Paisley Road, except to a small extent to the east of Ibrox Hill, and there may be a small reserve of the mineral beneath the western part of Bellahouston Public Park. The northern limit of the workings was formed in part by a fault which passes a few hundred feet to the north of Moorepark Boiler Works, and there is probably an area beyond this also worthy of exploitation, were it not for the extension of the city in this direction.

In the Titwood bore (Plate VII., Fig. 6) the Ironstone is replaced by a thin coal, as is also the case in a bore 500 yds. to the east of East Henderston. South of the line which joins these two localities one bore only, situated beside the Hole Burn, 500 yds. south by west from the Mains of Newlands, has reached the position (see Plate VII., Fig. 3). Here also the Ironstone is either wanting or replaced by a thin coal, while the only record in the area near Barrhead leaves room for the same alternatives. It is probable therefore that the seam is not developed as an ironstone in this district, except within 2 miles of the River Clyde.

The Upper Garscadden Blackband Ironstone is never a workable seam in this district.

The *Black Metals* of the Kilsyth area are, however, rather typically developed, and consist of 10 or 12 fms. of blaes, occurring midway between the Govan Blackband and the Titwood Gas Coal, and interspersed with bands of clayband ironstone. It should be noted that in one part of the district a series of thickish ironstones occur from 2 to 3 fms. above the base of the Black Metals, in the position of the California Claybands. These are recorded in—(1) the bore to the east of East Henderston, (2) the Titwood bore, and (3) the Newlands bore, all already referred to. At the horizon mentioned these bores give the following sections:—

(1)	Ft.	In.
Coarse irony fakes	0	5
IRONSTONE . .	0	5½
Dark blaes . .	0	9
Irony ribs . .	0	3
Dark blaes . .	1	0
IRONSTONE . .	0	5
Dark blaes . .	2	11
IRONSTONE . .	0	6

(2)	Ft.	In.
IRONSTONE .	0	5
Till . .	1	9
IRONSTONE .	1	1
Till . .	0	10
IRONSTONE .	0	3
Till . .	1	7
IRONSTONE .	0	6

(3)	Ft.	In.
IRONSTONE .	0	4
Blaes . .	1	9
IRONSTONE .	1	3
Blaes . .	2	0
IRONSTONE .	0	5

The thickest ironstone in (2) and (3) may possibly correspond to the marine band, in the Black Metals. If so, its limy character might detract from its value as an ironstone. Apart, however, from this possibility, the bands appear to be thick enough to deserve attention.

Gas Coal of Titwood (*Knightswood Gas*).—This seam does not always contain gas coal, and is hardly a workable subject except in the eastern part of the district considered. It was formerly worked, among other localities, near Govan and Ibrox, and, more recently, a fairly large area was wrought from the Lochinch Pit, to the north of Pollok House. Here the thickness was 2 ft. (see Plate VII., Fig. 5), and the seam contained 6 or 8 in. of gas coal in the centre. This may be taken as an average section, but the thickness of gas coal increases from south to north, and there are various records between this point and the river, in which it amounts to or exceeds a foot.

In the old Titwood Pit, where the total thickness of coal is given as 1 ft. 10 in., the seam was named the "Splint," but was elsewhere known as the "Titwood Gas." The former name was used at the pit to the north of Pollokshaws, which also worked the Pollokshaws Ironstone (see p. 59), and at an old pit just to the north of Cowglen. Between these two localities a bore gave the following section:—

	Ft.	In.
Hard dark grey plies	2	6
Dark blaes	2	5
Ironstone	0	2
Dark blaes	1	1
Ironstone	0	4
SOFT COAL	0	2
GAS COAL	0	4
SOFT COAL	1	10
Hard blaes	0	6

This bore was put down "in the sheep park near Pollokshaws," and probably not very far from the building known as Sheeppark. It will be further referred to as the Sheeppark bore.

In the deeper part of the area to the south the seam does not appear to contain any gas coal, though it has not very often been reached by boring. The Newlands bore gives only 14 in. of free coal, while the old Orchard bore, near Orchard, to the north of Giffnock (see Plate VII., Fig. 1), gives 2 ft. 11 in. of "soft coal" in the position, though it is not very certain how far this figure can be regarded as reliable. In the western part of the area, as already stated, the development as a whole is inferior. A 1 ft. 8 in. coal was found 18 fms. below the Stone Coal in a bore put down from the floor of Nitshill Quarry, but it is probable that this corresponds to a thin seam 8 and 10 fms. below the representative of the Gas Coal in the Newlands and Orchard bores respectively. If this be the case the Gas Coal is perhaps only 8 in. in thickness in the Nitshill Quarry bore, and may be even poorer in a bore somewhat west of the quarry, which gives the following section on the horizon of the lower coal just mentioned:—

	Ft.	In.
Fakes and blaes		
GAS COAL	1	7½
Dark fakes and blaes	5	6
Hard sandstone plies	0	5
COAL (splint)	1	5
Blaes	0	1
Sandstone plies		

In any case the Gas Coal cannot exceed 4 in. in thickness in a bore near Parkhouse. A bore near West Arthurlie passed through the following seam, probably a little more than 20 fms. below the Barrhead Main:—

	Ft.	In.
Blaes	3	8
CLAYBAND IRONSTONE . . .	0	9½
FOUL PARROT COAL	2	6
SOFT COAL	0	1
Fireclay and blaes	1	2

but in this case also it is uncertain that we are really dealing with the Gas Coal.

The Lochinch workings already mentioned are bounded to the south by a fault with at least 30 fms. downthrow. The extent of the workings from the Cowglen and Pollokshaws Ironstone Pits is unknown, but a fairly large area of workable coal may be present between them and to the south of the fault referred to. Further south the Coal has not been touched, but it increases in depth, and it is uncertain for what distance it maintains a workable thickness in this direction.

Radical Coal.—We have no definite knowledge as to the working of this seam, which is the equivalent of the Jubilee Coal in the area north of the Clyde.

The Coal appears to reach its greatest thickness in the neighbourhood of the old Titwood Colliery, where it measured 2 ft. 4 in. of "gas and free" coal, with a "till" roof (most probably blaes), and a pavement of "grey plies." A bore half a mile to the west found a foot of "hard and sulphury," resting on 1 ft. 4 in. of soft, coal. From this point the seam thins towards the north and west, measuring only 1 ft. 7 in. in the shaft of the old Lochinch Pit (see Plate VII., Fig. 5). It also thins to the south, being 1 ft. 5 in. thick in the Sheeppark, and 1 ft. 7 in. thick in the Newlands bore, but increases somewhat in thickness near Giffnock, where it is represented by 2 ft. 5 in. of "soft parrot coal" in the Orchard bore. There seems little prospect that the seam will prove of value in the western part of the Arden Basin.

Second or Pollokshaws Ironstone and Coal.—This seam was wrought as an ironstone in an old pit just west of the Glasgow and Kilmarnock railway, a short distance to the north of Pollokshaws. The section here is unknown, but the ironstone was almost certainly a blackband. At Titwood Colliery 15 in. of coal were overlain directly by 7 in. of ironstone, but the latter was absent at Lochinch, where 17 in. of coal only were present in the position. In the Sheeppark bore the section is as follows:—

	Ft.	In.
IRONSTONE with sand	0	7
Dark blaes	0	10
COAL	1	3

Here the ironstone was most likely an impure clayband, but the Orchard bore records:—

	Ft.	In.
IRONSTONE	0	2
Black blaes	1	3
PARROT COAL	0	9
IRONSTONE	0	4
PARROT COAL	0	5
ROUGH COAL	0	6

the lower ironstone being in all probability a blackband (Plate VII., Fig. 1).

Stone Coal.—The section of this seam at Cowglen Colliery (see Plate VII., Fig. 4) was:—

	Ft.	In.
Rock	1	4
COAL	0	10
Stone	0	10
COAL	1	0

In the Sheeppark bore the leaves of coal are 4 and 14½ in. in thickness, with a 13-in. parting of dark blaes. At Titwood Colliery the latter is replaced by 4 in. of "daugh," separating 9 in. and 14 in. of coal, while the section at Nitshill Quarry was "coal with thin irregular strata of blaize, 2 ft. 6 in." These records show a thickness above the average, which for the greater part of Renfrew 13 S.W. may be taken as 6 and 9 in. of coal for the two leaves respectively. In the Lochinch field the seam appears to consist of one bed less than a foot thick. Westwards from Nitshill also the coal is thinning, though there is a record of 15 in. in a bore close to Parkhouse.

The fact that the Stone was formerly known as the West Cowglen Coal would seem to imply that it was at one time wrought at that locality. In the "New Statistical Account of Scotland,"* it is stated that, at the Nitshill Quarries, "the stratum of coal could only be wrought by mining." As a bore a short distance to the west records only 7 in. of coal on this horizon, the mining is not likely to have been very extensive, and apart from the two localities noted, the seam does not appear to have been wrought within the district.

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* Vol. vii., 1845, Renfrewshire, p. 153.

Between the Stone Coal and the next in order there is present, near Nitshill, the lower of the two sandstones which were formerly worked at Nitshill Quarry (see p. 97).

Two-feet or Satturland Coal.—This coal probably received the former name at Cowglen Colliery, where the section was:—

	Ft.	In.
"Dogger"	0	4
Till	2	9
COAL	2	2
Rock	1	1

It was barely recognisable in the Sheeppark bore and at Lochinch Colliery, but recovers its thickness to the east, as it measured 1 ft. 8 in. at Titwood and 2 ft. 3 in. in the Newlands bore (Plate VII., Fig. 3). Further south it appears to have been recorded, with a thickness of 1 ft. 10 in., at Orchard.

In the western part of the district the seam was inferior in thickness, but measured 1 ft. 8 in. in the neighbourhood of Salterland (Satturland), where it was wrought to a considerable extent. The thickness was the same in the Nitshill Quarries, where the coal overlay the sandstone already referred to, and was in turn overlain by fireclay. The latter is a usual feature in this neighbourhood, and varies from 3 to 5 ft. in thickness. The coal is worthless in the Parkhouse bore, quite a short distance to the south of Salterland.

First Ironstone Coal and Ironstone.—This seam is also referred to as the "First Blackband and Coal," in distinction from the Second, or Pollokshaws, Blackband. We have no information as to the area of development or former working of this Blackband. The thin coal which was taken as marking its position in the Cowglen section is, however, a rather constant feature.

A day-level was formerly visible on the side of the Paisley Canal, now replaced by a railway, about 200 yds. south-west from where the latter is crossed by Nithsdale Road. This worked an oil shale and an ironstone, of which the following appears to be the section, as recorded in two neighbouring bores:—

	In.
PARROT COAL	2
SHALE	5
CLAYBAND IRONSTONE	2
SHALE	3
Blaes	2
COAL	8

The position is 15½ fms. above the Gas Coal, corresponding fairly well with that of the First Ironstone, though the ironstone shown in the bores is clayband.

The coal is 10 in. thick at Cowglen, and on the same horizon at Titwood there were 2 in. of "ironstone" resting on 11 in. of coal. In the Orchard bore the section reads:—

	Ft.	In.
WILD PARROT COAL	0	4
IRONSTONE BALL	0	1
WILD PARROT COAL	0	6
ROUGH COAL	1	1

The seam cannot be identified with certainty round Nitshill, but may be one of two thin coals (one of which contains a 10-in. rib of parrot coal) which lie a few feet above the Satturland seam.

A 1 ft. 9 in. "rough coal" occurs about 2 fms. above the First Ironstone Coal in the Orchard section.

Above the horizon of the Ironstone there follows, but only locally, the upper and thicker of the two sandstones which were wrought in the Nitshill Quarries. This sandstone underlies the *Quarry* or *Nine-inch Coal,* which appears to be also of local occurrence, although a foot in thickness at Cowglen.

Geordie's, Stinking, Rough, Smithy and Sclutty Coals.—A group of from four to six occasionally workable coals occurs at a level of, roughly, from 40 to 30 fms. below the Index Limestone,* and can be traced over a considerable part of the area under discussion. These seams are typically developed near Cowglen (see General Section, on pp. 53–54 and Plate VII., Fig. 4), and may be conveniently referred to as the Cowglen Group. It is not known, however, how many of the group were worked at this locality. The Stinking Coal was certainly raised, and the fact that the others derive their names from these workings might imply that each seam received some attention. The "New Statistical Account of Scotland" states that five seams had been wrought at the time of its publication,† but this may include the Gas (or Splint) and possibly other of the lower coals.

Six seams belonging to this group were met with in the shaft of Lochinch Pit (Plate VII., Fig. 5). It is probable that the highest of these, only 13 in. in thickness, was an extra seam and that the next in order, which was worked to a certain extent under the name of the Rough or Cherry Coal, represents the Sclutty (or Slaty) of Cowglen. The section was:—

	Ft.	In.
Fakes		
Daugh	0	3
COAL	1	7
Slate	0	2
COAL	1	3
Rock		

This coal was rather splinty in character and contained a large percentage of ash. The supposition above expressed gives a thickness of 1 ft. 4 in. for the Smithy, 2 ft 3 in. for the Rough Coal proper, 1 ft. 5 in. for the Stinking, and 1 ft. 2 in. for the Geordie's Coal. Between Lochinch Colliery and the Clyde the condition of these coals has not been adequately proved, while there is little area free from buildings where they are likely to be present.

Eastwards from Cowglen the positions of the five seams can be easily identified in a bore near Auldhouse, and in the Newlands bore already referred to. In the latter there is no coal in the group more than 1 ft. 7 in. thick. Further east, however, in a bore on Merrylee Farm, the Sclutty Coal has a thickness of 25 in. (see Plate VII., Fig 2); this seam, or possibly another member of the group, was formerly wrought at Cathcart, just west of the cemetery, with a thickness of 18 in. and at a depth of about 40 fms. Two old shafts close to the White Cart, on the opposite side of the cemetery, are also no doubt connected with the presence of this series.

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* The distance was erroneously given as 12 to 22 fms. in the "Geology of the Glasgow District" (*Mem. Geol. Surv.*), 1911, p. 39.

† Vol. vii., 1845, Renfrewshire, p. 36.

The Rough and Stinking Coals maintain their thickness, and are being wrought on a fairly large scale, under the name of the Main and Jewel Coals, at the present Giffnock Colliery. The section is:—

		Ft.	In.
Blackband Ironstone		1 in. to 0	6
Blaes		0	5
Main Coal	Coal	0	5
	Gas Coal	0	2
	Coal	0	10
	Gas Coal	0	3
	Coal	0	5
Blaes		2 ft. to 4	0
Ironstone Balls		0	6
Parrot Coal		0	6
Jewel Coal		1 ft. 11 in. to 2	3
Sandstone			

In the Orchard bore the two seams measure 2 ft. 2 in. and 2 ft. 5 in. respectively; the Geordie's Coal, about 2 fms. below the Jewel, is 1 ft. 8 in. in thickness. The probable equivalents of the Smithy and Sclutty Coals lie about 10 and 11 fms. respectively above the Main, this abnormal distance being due to the intervention of a post of sandstone. The sections are:—

		Ft.	In.
White sandstone		3	5
Foul Coal (Sclutty)		2	2
Grey fakes		4	4
Dark blaes		1	0
Soft Coal	Smithy	1	9
Dark fireclay		0	3
Foul Coal		0	4
Dark fakes		2	5

Somewhat further to the east this group of coals becomes unrecognisable.

Between Cowglen and Barrhead the group always contains one or two workable, though sometimes barely workable, coals. A coal named the Boghouse was raised between Nitshill and Priesthill, and has been stated to be the Sclutty Coal of the Cowglen section.* In the old Boghall Pit, by the roadside 300 yds. to the north-west of Parkhouse, four coals, with the following section, were present on the level of this group:—

	Fms.	Ft.	In.
Boghall Coal (wrought)	0	1	10½
Strata	1	4	10
Darnley Coal (partly wrought)	0	1	8
Fireclay	0	4	4
Coal	0	1	8
Sandstone and fakes	0	5	0
Coal	0	1	2½

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* Hugh M'Phail, "On the Carboniferous Sections of the Levern Valley, Renfrewshire," *Trans. Geol. Soc. Glasgow*, vol. iii., 1871, p. 254.

A bed of "daugh" which occurs about 2 fms. below the lowest coal may possibly represent the Geordie's Coal of Cowglen, and the four seams of the above section may thus be correlated with the Sclutty, Smithy, Rough and Stinking Coals in descending order.

Barrhead Main Coal.—This coal was rather extensively wrought in the neighbourhood of Barrhead. Very little is known as to its relations, and less as regards its quality, but its thickness is recorded as from 3 ft. 6 in. to 4 ft., and it was certainly a member of the preceding group. It is stated that on the south-west of the town the seam was in two parts, with a stone rib in the centre which increased in thickness towards the dip. An old bore to the south-west of Arthurlie showed the following section:—

	Thickness.		Depth below Index Limestone.		
	Ft.	In.	Fms.	Ft.	In.
COAL	0	11	29	2	11
Band	0	3	29	3	2
COAL	3	9	30	0	11
Fireclay (sandy)	2	4	30	3	3
Blaes	1	8	30	4	11
COAL	1	9	31	0	8
Blaes	0	6	31	1	2
Sandstone	14	4	33	3	6
Blaes	1	7	33	5	1
COAL	2	9	34	1	10
Sandstone	2	0	34	3	10
Blaes	1	10	34	5	8
IRONSTONE	0	6	35	0	2
Fireclay	0	7	35	0	9
COAL	2	2	35	2	11

The four thickest seams are probably the four coals proved at Boghall, which have thus considerably increased in thickness. It is uncertain, however, which coal or coals in this section correspond to the Barrhead Main, which has not been worked to the south-east of the large Barrhead Fault in the neighbourhood of Arthurlie. The depth from the surface to the lowest member of the group is 86 fms., and the bore may be taken as showing that on any hypothesis as to correlation, there is probably a considerable reserve of workable coal on the downthrow side of that fault.

Overlee Coal.—A coal is seen, when the water is low, on the west bank of the White Cart, near Overlee. This coal was sunk to, a few years ago, at a point not far from the river, but was found to have been previously worked. The section, as shown by a stoop, was:—

	Ft.	In.
Sandstone		
Dark grey fakes	2	9
SLATY COAL	0	6
COAL	3	4
Sandstone		

The position of this coal is about 12 fms. below the Index Limestone. It may be this seam, or one somewhat lower, which is seen, beside an "ingoing eye," on the opposite bank of the river, some 400 yds. further north. Here the section is:—

	Ft.	In.
Blaes	6	0
COAL	1	0
Sandy fireclay	1	6
COAL	2	2
Sandstone	5	0

In any case the coal nearer to Overlee must be extremely local in its occurrence, and higher in the sequence than any of the Cowglen Coals.

Two or three thin "floats" or sills of teschenitic dolerite are intruded among the strata at levels ranging from 0 to 20 fms. below the Index Limestone. They have been cut in bores, and are exposed along the valley of the White Cart above Cathcart. One of these sills, intruded immediately below the Index, gives rise to the waterfall below Linn House; the cliff below Cathcart Castle is also formed by a similar sill, which is here cut off by a north-westerly fault. These sills are prolongations of a thicker intrusion, known as the Aikenhead Whin, which comes to the surface further east at Aikenhead. They are confined to the south-eastern part of the present district, where they are fortunately not thick enough to have any appreciable influence on the underlying coals.

Structural Features.—Coals belonging to the Cowglen Group have been worked in an almost continuous belt along the north-western margin of the Arden Basin, from some distance south-west of Barrhead to the neighbourhood of Cowglen. The workings were at no great depth, but at present two members of the group are being raised at Giffnock, at depths which vary from about 70 to over 100 fms. It is almost certain that in other parts of the basin this group will be worked in the future at greater depths than have hitherto been attained.

Towards Barrhead the coals have thickened, and the main cause of the limitation of the workings was the large fault which roughly follows the line of Main Street and Darnley Road, and may be conveniently named the Barrhead Fault. The amount of throw is difficult to estimate, but may approach 60 fms. The bore near Arthurlie already quoted shows the condition of the seams upon the downthrow side.

As regards the structure of the field, the strata within the central part of the basin over which the Arden Limestone, as shown on the map, is present, are inclined at a very low angle, and faults are remarkably few. There is, however, a 30-fm. fault quite close to the bore near Arthurlie. In the deepest part of the basin, near Dubs, the Barrhead Main Coal should be met with about 140 fms. from the surface. The thick beds of sandstone that overlie the Index Limestone in this district may hold considerable quantities of water, as their outcrop round the basin is not sealed by a boulder-clay covering. But this question can only be decided by boring, and it should be noted that comparatively little water was met with in a deep bore near Thornliebank, which passed through the sandstones in question.

On the south side of the basin the seams again become fairly shallow, as the Index Limestone comes to the surface near Auchinback and the Waulkmill Glen Reservoir, and further east near Cleuch.

There is, however, an almost entire absence of information as to their condition in this area, where they have probably never been worked, though there is some doubtful evidence of the existence of an old mine near Cleuch. Since a railway now follows this strip of country, it would be well worth while to test the area by boring.

Regarding the district as a whole, the thickest coal seam is undoubtedly the Hurlet, which was worked over an extensive area, and to a somewhat considerable depth (see p. 49). It is, however, rather poor in quality, which was probably the reason which led to its abandonment. In view, however, of its thickness and persistence, it is by no means improbable that this coal may be reopened at some future date. In the Limestone Coal Group there is no seam of very outstanding thickness, but the coals are fairly numerous, and nearly all of those described reach workable dimensions in some part or other of the district. Further boring will be necessary in any individual area where it may be proposed to sink. When a further advance in mining methods makes it possible to work thin seams at a greater depth than has hitherto been practicable, this district will come more into prominence, and even under present conditions there are areas, such as that near Barrhead, of which the most has not yet been made. E. M. A.

UPPER LIMESTONE GROUP.

Barrhead and Giffnock.

Renfrew, 12 N.E, S.E.; 13 N.W., S.W.; 16 N.E.; 17 N.W.; Lanark, 10 N.W.

The strata between the Index and Calmy Limestones in the district of Barrhead and Giffnock afford what is now accepted as the type sequence for the West of Scotland. They occupy the centre of the Arden Basin, which extends in an east or east-south-east direction from Barrhead to the White Cart Water in the neighbourhood of Clarkston, and is bounded on the south by the large fault which brings up the volcanic rocks of Eaglesham and Mearns. North-eastwards the Upper Limestone Group reaches as far as the immediate neighbourhood of Glasgow.

There are several natural sections, as well as artificial surface exposures, in the district, which are of much geological interest. Among the latter may be mentioned the railway cuttings near Auchinback and Nitshill Station, and the quarries near Giffnock; among the former the Springfield, Waukmill and Rouken Glens, which are formed respectively by the Aurs, the Brock and the Auldhouse Burns. These sections have been described in "The Geology of the Glasgow District,"* and will not be here referred to except in connection with points of economic interest. The following may be taken as a general section of the Upper Limestone Group in the district, though the sequence is liable to some local variation.

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* *Mem. Geol. Surv.*, 1911, pp. 40–45.

GENERAL SECTION OF LOWER PART OF UPPER LIMESTONE GROUP. DISTRICT OF BARRHEAD AND GIFFNOCK.

	Thickness.			Depth.		
	Fms.	Ft.	In.	Fms.	Ft.	In.
Strata	18	0	0	18	0	0
CALMY OR ARDEN LIMESTONE	2	0	0	20	0	0
Strata	0	5	0	20	5	0
UPPER ARDEN COAL	0	1	0	21	0	0
Strata	1	4	0	22	4	0
LOWER ARDEN, AUCHINBACK, or NORTH BRAE COAL	0	2	0	23	0	0
Strata	18	0	0	41	0	0
Blaes	3	5	0	44	5	0
UPPER ORCHARD LIMESTONE	0	1	0	45	0	0
Blaes	4	4	0	49	4	0
LOWER ORCHARD LIMESTONE	0	2	0	50	0	0
Strata	1	0	0	51	0	0
Horizon of South Arthurlie Coal	0	0	0	51	0	0
Strata, consisting in part of the district mainly of sandstone	12	2	0	63	2	0
MOOR ROCK COAL	0	1	0	63	3	0
Sandstone ("Moor Rock")	5	0	0	68	3	0
Sandstone ("Giffnock or Liver Rock")	5	0	0	73	3	0
Blaes	0	3	0	74	0	0
LIMESTONE }	0	1	6	74	1	6
Blaes } LYONCROSS LIMESTONE	0	1	6	74	3	0
LIMESTONE }	0	3	0	75	0	0
Strata	2	0	0	77	0	0
LYONCROSS COAL	0	3	0	77	3	0
Strata, including usually a large proportion of sandstone, with bands which are gritty or pebbly in character (the "Barrhead Grit")	21	1	0	98	4	0
LIMESTONE	0	2	0	99	0	0
Strata	10	0	0	109	0	0
INDEX OR COWGLEN LIMESTONE	1	0	0	110	0	0

Index or Cowglen Limestone.—This is a grey "calmy" limestone, usually containing encrinites and shells of *Productus.* The crop can be followed with tolerable accuracy round the western half of the Arden Basin. The Limestone was wrought, with a thickness of 10 ft., in a pit to the west of Wardhill, near Nitshill, but it is not now exposed at the surface except on the southern side of the basin between Barrhead and Busby. The overlying Barrhead Grit rests on the limestone near Barrhead with a slight unconformity, and is often in direct contact with the fine-grained sandstones beneath it. This relation is well seen in the railway cutting to the south of Arthurlie House, and also further along the railway at Auchinback. The Limestone has been worked to a small extent near the latter locality. In addition, however, to the irregularity just noticed, it is here too ferruginous for building purposes, and hardly of good enough quality for a cement. Where again seen, at the east end of the Waukmill Glen Reservoir, it is 6 ft. in thickness, and has weathered to an ochreous clay.

At the eastern end of the basin the Limestone was found in a well at Cleuch, and is seen on the left bank of the White Cart a little below the Overlee Railway Viaduct. Further north the seam has been to a small extent mined and quarried alongside the river and in the neighbourhood of Cathcart.

The Index Limestone was also wrought opencast between Kennishead and Cowglen; from the latter locality it derives its local name. It is here stated to be 5 ft. in thickness, and to consist of four distinct beds, some of which produced lime of a pure white, and others of a blue colour.*

The following analysis was made by the late Mr. J. S. Grant Wilson†:—

INDEX LIMESTONE.

Left bank of White Cart, 110 yds. north-west of railway viaduct, and half a mile north of Busby, Renfrewshire.

Medium to dark-grey, fine-grained limestone, with splintery fracture, and containing carbonaceous particles.

SiO_2	16·64
Al_2O_3	2·19
Fe_2O_3	1·5
MnO	·44
CaO	41·78
MgO	2·15
Alkalies	Undetd.
CO_2	34·88
H_2O above 100° C.	·15
	99·73
$CaCO_3$	74·61
$MgCO_3$	4·51

Cementation Index = 1·14.

The CO_2 satisfies all the lime and the magnesia, less ·21 per cent. In this limestone there must be a considerable percentage of free silica.

The thinner limestone which overlies the Index at a distance of about 10 fms. is the equivalent of the cement-stone found at Huntershill (see p. 91). It attains a thickness of over 3 ft. in some parts of the area, but westwards is usually wanting, the pebbly sandstones of the Barrhead Grit coming right down to the Index position. The Grit extends upwards near Barrhead to the Lyoncross Coal, and has thus a total thickness in this neighbourhood of from 30 to 40 fms. It forms a well-marked escarpment between Barrhead and Nitshill in which there are many deserted quarries, but none that was worked on any large scale, as the material was too coarse for a good building-stone.

Lyoncross Coal.—This coal was most recently wrought, about the year 1905, at the present Giffnock Colliery, and, although poor in quality, was used to a small extent as a household coal. The thickness was 3 ft., but the inferiority referred to soon led to the abandonment of the workings. The Coal maintains its thickness to the south at least as far as the Orchard bore, where it measured 2 ft. 10 in., with a roof and pavement of blaes. It has also been found in fair thickness in bores near Braidbar and Williamwood. Here, however, the journals are conflicting in their evidence, and show the lower part of the seam usually as "foul coal" or "blaes with coal."

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* *The New Statistical Account of Scotland*, vol. vii., 1845, Renfrewshire, p. 36.

† Quoted from "Geology of the Glasgow District" (*Mem. Geol. Surv.*), 1911, p. 227.

The Coal is certainly thinner at its outcrop beside the dam on the Auldhouse Burn, above the Rouken Glen, where it measures only about a foot. It also appears to be thinner to the north, and is almost wanting to the west of Giffnock Colliery. It must, however, recover in thickness further to the west, as it has been worked at intervals right round the western part of the Arden Basin.

There are, for instance, old workings on the sides of the Nitshill railway cutting, where the coal is said to have varied from 1 ft. 4 in. to 2 ft. in thickness, but both here and somewhat further west near Parkhouse, the area of coal available must have been sharply limited by the Barrhead Fault. The seam appears to have been rather more extensively wrought to the south of Barrhead, and was about 1 ft. 6 in. in thickness in the Springfield Glen (to the south of South Arthurlie Print Works). Near Lyoncross itself the thickness is given as from 1 ft. 4 in. to 2 ft. 2 in., and in the Waukmill Glen as 1 ft. 10 in., though only 14 in. of foul coal could be observed at the outcrop. The quality of the Coal in the western part of the district was probably not much better than at Giffnock. A bore near the centre of the basin, about 1000 ft. east by north from Dubs, shows only 2 in. of coal on this horizon, though possibly the bore may have passed through something in the nature of a "want."

Lyoncross Limestone.—This seam can be seen in various natural sections, more especially in the western part of the district. It is a grey, ochreous-weathering, cement-limestone, mainly unfossiliferous, and usually in two divisions, with a parting of blaes. It was at one time confused with the Index Limestone, and its recognition as a separate seam is due to the late James Stewart of Williamwood, who did much to unravel the geology of this district.*

The Lyoncross Limestone is present in the Nitshill railway cutting already referred to, in the Springfield Glen, and in the Waukmill Glen, where it has a thickness of 4 ft. 6 in., and was worked until a few years ago as a cement. The product had the property of setting quickly, and was used for fireproof ceilings, and for work between tide-marks. It was, however, of a deep ochreous colour, and had only half the strength of Portland cement.

Further to the east the seam is best exposed on the banks of a small hollow about 600 yds. to the west of Cleuch. Here also it has been worked, but for what purpose is unknown. The following analyses† of the limestone were made by the late Mr. J. S. Grant Wilson :—

LYONCROSS LIMESTONE.

I.

From mine, Waukmill Glen, 1¼ miles south-east of Barrhead, Renfrewshire.

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* "Notes on the Limestones in the Parishes of Cathcart and Eastwood, Renfrewshire," *Trans. Geol. Soc. Glasgow*, vol. vii., 1885, p. 158.

† Quoted from "Geology of the Glasgow District" (*Mem. Geol. Surv.*), 1911, p. 226.

A medium-grey, solid, fine-grained limestone, with a slabby facture.

SiO_2	8·18
Al_2O_3	4·85
Fe_2O_3	9·34
MnO	·38
CaO	27·89
MgO	11·31
Alkalies	Undetd.
CO_2	38·26
H_2O above 100° C.	·02
	100·23
$CaCO_3$	49·80
$MgCO_3$	23·76
$FeCO_3$	13·54

Cementation Index = ·79.

The CO_2 in this analysis satisfies all lime, magnesia and two-thirds of the iron. The probable combination of the rest of the constituents will leave little free silica.

II.

In wooded hollow on left bank of stream, one-third of a mile a little north of west of Cleuch, and 1½ miles W.N.W. of Busby, Renfrewshire. Specimen taken from the centre of a seam 20 in. in thickness.

Dark-grey limestone, breaking into cubical blocks with a semi-conchoidal fracture.

SiO_2	6·38
Al_2O_3	1·79
Fe_2O_3	11·6
MnO	·41
CaO	29·54
MgO	11·37
Alkalies	Undetd.
CO_2	39·58
H_2O above 100° C.	·05
	100·72
$FeCO_3$	16·82
$CaCO_3$	52·75
$MgCO_3$	23·88

Cementation Index = ·61.

The CO_2 satisfies all the lime, magnesia and nine-tenths of the iron. A little free silica is probably present.

Giffnock Freestone.—This name is sometimes applied to the sandstone which overlies the Lyoncross Limestone in the Giffnock district, and more particularly to the " Liver Rock " which is of better quality than the overlying " Moor " or " Grey Rock." A description of these sandstones will be found in the section dealing with Sandstone Quarries (p. 97). As a workable subject the sandstone is rather local; it thins laterally, and passes into faky sandstone or an alternation of sandstone and fakes. There is an accompanying diminution of the distance between the Lyoncross and Lower Orchard Limestones, which in many parts of the district is less than 20 fms.

A thin seam, which has been named the *Moor Rock Coal,* occurs above the Moor Rock at New Braidbar Quarry. It is here 14 in. in thickness, but dies out when followed along the quarry face. It is found again, however, in a bore to the south of Williamwood, where 19 in. of coal were recorded, and in three bores near Clarkston, where the average thickness was a foot. A few inches of coal are elsewhere generally present on this horizon, but it is very unlikely that the seam is of any economic value.

A thin coal generally occurs 1 or 2 fms. below the Lower Orchard Limestone (see Plate VII., Fig. 1). The thickness is usually only a few inches, but a coal which was wrought to a small extent to the east of South Arthurlie is probably on this horizon. The section was here 1 ft. of gas coal upon 1 ft. of dross coal. In a bore at South Arthurlie Print Works the thickness of a probably equivalent seam is 19 in., but the bore near Dubs already referred to found only 6 in. of coal in this position.

Lower Orchard Limestone.—This limestone was formerly well known as a natural cement, and was quarried along the crop, as shown on the six-inch Geological Sheet (Renfrew 13 S.W.) on both sides of Orchard, and eastwards to Williamwood. It was also mined to a certain extent near Orchard. The section formerly exposed at the surface showed 2 ft. of cement limestone, underlying 15 ft. of blue blaes with cement balls. This blaes was one of the best known fossiliferous horizons in the West of Scotland, but the sections are now, unfortunately, almost all obliterated.

The material produced was classed as a hydraulic or "Roman" cement, and used for sea-walls and "wet" work of all kinds. The workings were discontinued through the competition of Portland cement, which is stronger, sets more slowly and can be produced at an equal price.

The following analyses of the stone (I.) before and (II.) after calcining were made by Prof. Frederick Penney, F.R.S., late Professor of Chemistry, Andersonian University, Glasgow:—

LOWER ORCHARD LIMESTONE.

I.		II.	
$CaCO_3$	58·2	CaO	51·81
$MgCO_3$	7·5	MgO	5·68
$FeCO_3$	10·7	FeO	10·57
$MnCO_3$	0·4	Soluble Silica	17·03
Phosphates	0·8	Insoluble Silica	9·07
SiO_2	16·4	Al_2O_3, etc.	5·84
Al_2O_3	2·1		
Organic matter	2·8		
K_2O and Na_2O	0·5		
Moisture	0·6		
	100·0		100·00

The seam was also worked at Little Auchinback, near Barrhead, where it was 2 ft. 6 in. in thickness, and of excellent quality. A trial was also made in the Waukmill Glen, but the cement, though of good quality, measured only 6 in., and was thus too thin for profitable working.

The Limestone is seen, a foot thick, in the bed of the Auldhouse Burn (Rouken Glen), about 300 yds. to the south of Thornliebank House. This band is only visible at low water, and must be distinguished from the Upper Orchard Limestone, which forms a more conspicuous feature a little lower down the glen. Apart from this locality there is an absence of natural sections, but numerous bores have proved that the seam is almost invariably present in the deeper part of the basin. A bore to the west of Clarkston shows the bed with a thickness of 1 ft. 9 in. at a depth of 9 fms., and it is similarly developed at 11 fms. in another bore to the north of the village. The Cement, with a suitable thickness, could thus be reached quite near the surface, and but for the competition above referred to, would no doubt have been more extensively worked.

The thick mass of blaes which overlies the Lower Orchard Limestone, is an even more constant feature than the limestone itself. It can be identified in every bore which has proved the position in the Central Coalfield, and can be traced into Ayrshire and Fife. Four or five fathoms above the base in the present district is another thin band of limestone, which, like the former, was first identified in this neighbourhood. It has been named the *Upper Orchard Limestone.* Its occurrence in the Rouken Glen has already been noted. It is there in three bands, which, along with the blaes immediately above them, are highly fossiliferous. The Limestone measures a foot in the Waukmill Glen, and is recorded in various bore journals, with a thickness which is on the whole a little less than that of the underlying seam. It has also the character of a cement limestone, but has never been worked.

Arden Coals and Darnley Fireclay.—Two coals occur below the Arden Limestone, with the approximate positions and thicknesses shown in the general section. These correspond, though perhaps not individually, to the Hirst Coals of the district north-east of Glasgow.

It was probably the lower of these coals which was formerly wrought to a small extent beneath the limestone workings near Darnley Bridge and near Dovecothall. The lower seam was also wrought on the south side of the basin, near the farm of North Brae, and was known as the North Brae or Auchinback Coal. It is stated to have been a splint coal of inferior quality; one section is given as:—

	Ft.	In.
Rock	3	0
COAL	2	3
Fireclay	1	0

The deepest workings were from an old pit near the junction of the Aurs and Brock Burns. Here "this coal was reached at about 18 fms., being considerably in the dip of the other shafts, and from 3 to 5 ft. in thickness, gradually becoming thicker towards the trough." * This increase in thickness, if it existed, cannot have continued very far, as in the bore near Dubs Farm, already referred to, the section is:—

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* Hugh M'Phail, "On the Carboniferous Sections of the Levern Valley Renfrewshire," *Trans. Geol. Soc. Glasgow*, vol. iii., 1871, p. 254.

	Ft.	In.
Fireclay	1	3
FOUL COAL	2	0
Faky fireclay	2	10
COAL	1	2
Light fireclay	0	4

and it seems likely that only the lower division corresponds to the North Brae Coal.

The coal also deteriorates very rapidly to the east, becoming at the same time associated with a workable fireclay. The latter is wrought, under the quarried limestone, at the present Darnley workings to the west of the rifle range. Here an average section is:—

	Ft.	In.
LIMESTONE	9	0
Limy blaes or impure limestone	4	6
Edmondia slate	0	4
FOUL COAL	1	0
Blaes	0	6
FIRECLAY	2	0
COAL and coaly blaes	2	0
FIRECLAY	4	6

There is little doubt that the lower of the two coals in this section is the North Brae Coal, but its condition is so poor that it cannot even be used in the kilns for the treatment of the fireclay. The latter is obtained from the layers both above and below the coal, but the lower bed is rather the better in quality. The two are mixed in varying proportions and used in the manufacture of fire-bricks, pipes and sanitary ware.

Further to the east a bore near Arden Head found what is probably the lower coal with a thickness of 9 in. This seam is also probably represented by a splinty coal, with a thickness of at least a foot, seen by the side of the small reservoir, about 200 yds. to the south of Stanalane. Eastwards still, a bore "in Davieland" found the lower seam to consist of 1 ft. 6 in. of "good" over 10 in. "bad" coal, the roof being fakes, and the pavement sandstone.

The upper coal is even less promising. It appears, as a foot of impure splinty coal, in the Brock Burn section a short distance below the limestone, and is here, as at Darnley, directly overlain by the *Edmondia* slate, which, with its characteristic fossil, *Edmondia punctatella*, is a very constant feature throughout the Central Coalfield, and forms a ready means, in borings, of distinguishing the Calmy Limestone.*

Calmy or Arden Limestone.—This seam is at present only wrought at the Darnley Quarries above referred to. It is here about 9 ft. thick, being of somewhat better quality in the lower part, and unlike other limestones in this Group, weathers with a light grey colour. It is in itself poor in fossils, but beds in the overlying blaes are often crowded with small organisms. The lime produced was formerly to some extent employed for agricultural purposes, but is now used entirely for building.

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* See "Economic Geology of the Central Coalfield, Area V." (*Mem. Geol. Surv.*), 1916, Plate XII., Fig. 1, also Peter Macnair, "The Geology of the Rouken Glen and its Neighbourhood," *Trans. Geol. Soc. Glasgow*, vol. xii. (Part 3), 1906 p. 362.

The limestone and associated blaes can also be seen in the Waukmill Glen. Other outcrops of the seam on the map are inserted from bores, or from positions of obliterated quarries. The latter are known to have existed, among other places, at Arden, near Darnley Bridge and near Dovecothall; also in a detached outlier of the seam near Davieland. The following analysis* of the limestone from the present Darnley Quarries was made by the late Mr J. S. Grant Wilson:—

CALMY LIMESTONE.

Quarter of a mile east of Darnley House, and about 2 miles east of Barrhead, Renfrewshire. A light grey limestone, very fine-grained, with a cubical splintery fracture. Specimen taken from about the middle of a seam 10 ft. in thickness.

SiO_2	14·67
Al_2O_3	1·12
Fe_2O_3	1·54
MnO	0·37
*CaO	43·58
*MgO	1·71
Alkalies	Undetd.
*CO_2	36·34
H_2O above 100° C.	0·05
	99·38

***Or, calculated as carbonates of lime and magnesia**

$CaCO_3$	77·82
$MgCO_3$	2·59

Cementation Index = ·95.

Structural Features.—The Arden Limestone and Coals are found in three separate areas. The largest extends from Barrhead to Arden along the axis of the basin. The second area, which is barely detached from the first, occurs to the north and west of Darnley Hospital. The Limestone and Coals, on coming to the surface, are brought down again by faulting, the former having been wrought from an old pit at this locality at a depth of 12 fms. This area probably extends to near Kennishead, but its limits are uncertain. The third small area, near Davieland, has been already referred to.

The Orchard Limestones are present over a more extended area which includes and connects the three already mentioned, and as we descend in the series a greater space is occupied by each successive seam. Reference has already been made to the faulting of this district in the section dealing with the Limestone Coal Group (p. 64).

Probable Future Development.—The coals in this group are very poor in quality, and it is unlikely that they will receive further attention as long as the better coals of the Limestone Coal Group remain to be wrought. The two thickest limestones—the Index and Arden or Calmy—have in the main been worked out where they were most easily accessible, and it is unlikely that they will be pursued very far underground. The Lyoncross Limestone could probably be obtained at the surface, and the Lower Orchard Limestone could easily be reached by mining, if any alteration of circumstances should bring this quality of limestone again into use.

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* Quoted from "Geology of the Glasgow District" (*Mem. Geol. Surv.*), 1911, p. 224.

E. M. A.

CHAPTER V.

GLASGOW DISTRICT—(*b*) NORTH OF THE CLYDE.

Lanark, 1 N.W., S.W., N.E.; 5 N.E.; 6 N.W., S.W.; **Renfrew**, 8 N.E., S.E.; 9 S.W.; **Dumbarton**, 23 N.E., S.E., S.W.; 24 N.W., S.W.; 25 N.W., N.E.; 26; **Stirling**, 27 S.W., S.E.; 32 N.W., N.E.

CALCIFEROUS SANDSTONE SEDIMENTS.

Craigmaddie and Duntocher.

THE further information obtained by the Survey since the publication of "The Geology of the Glasgow District" in 1911, together with the results of recent work by other observers—among whom the names of Messrs. Peter Macnair, H. R. J. Conacher and James Neilson should be specially mentioned *—have led to certain modifications in the interpretation of the sections and the identification of the seams as expressed in the description of this district in the Memoir referred to above.

These changes are embodied in the following pages.

The upper sedimentary group of the Calciferous Sandstone Series, overlying the lavas of the Clyde Plateau, appears north of the Clyde within the limits of Area IV. in the Craigmaddie district, stretching from Milton on the east to Douglas Muir.

In this area a great mass of sediments, probably upwards of 600 ft. in thickness and mainly arenaceous in nature, lies between the lavas and the Hurlet Seam, the base of the Carboniferous Limestone Series. The actual junction of the sedimentary rocks with the lavas is not exposed, and is faulted out for considerable distances.

On the west side of Douglas Muir a basal bed of volcanic detritus has been mapped, but elsewhere has not been found. It may be absent round Craigmaddie and Craigend Muirs, where the lowest bed exposed is a quartzose conglomerate which is free from volcanic material, although it can be traced close up to the lava outcrop.

The overlying beds consist largely of coarse gritty sandstone with small pebbles of milky quartz. These beds form the barren uplands of Craigmaddie, Craigend and Douglas Muirs. In the last-named locality a bed of variegated marl can be seen among the grits in the streams south of Crossburn. Elsewhere, however, both the conglomerate and sandstones are remarkably free from pyroclastic material.

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* "The Stratigraphy of the Limestones lying immediately above the Calciferous Lavas in the Glasgow District," by Peter Macnair and H. R. J. Conacher, *Trans. Geol. Soc. Glasg.*, vol. xv. (Part 1), 1914, p. 44. "Notes on the Geological Survey Memoir—The Geology of the Glasgow District," by James Neilson, *Trans. Geol. Soc. Glasg.*, 1911, vol. xiv. (Part 3), p. 323.

These coarse gritty beds pass up into sandstones of a finer texture, which have been from time to time quarried for building-stone near Craigmaddie Reservoir: they are interleaved with thick beds of fireclay and hard "kingle" bands.

To the south and south-west of Douglas Muir a coal seam, 12 to 14 in. in thickness, occurs near the top of the series. A coal was also met with in the Tarfin bore, near Lennoxtown, 30 fms. below the Hurlet Seam.

The highest bed is a limy shale, crammed with small Producti and Rhynchonellids, covered by a few inches of dark calmy blaes with plants, *Actinopteria fluctuosa,* Goniatites, etc. This represents the Blackbyre Limestone of the Hurlet district, and is exposed at several localities. Near Lennoxtown it is seen in the stream sections at Balgrochan and in the Baldow Glen; also to the north-east of Dowan, east of Milngavie, where it is associated with an intrusion of dolerite.

The best section of the upper part of these sediments is perhaps that exposed in the Baldow Glen. The beds here consist for the most part of "kingles" and thick fireclays; the latter are often full of brown oolitic grains of iron ore, which have a deceptive resemblance to seeds or spores. The fireclays are followed above by a blue calcareous shale full of fragments of *Productus,* with thin bands of encrinite limestone already referred to as the equivalent of the Blackbyre Seam. This is succeeded by the Baldernock entomostracan limestone and the rest of the section is included in the Carboniferous Limestone Series.

A bluish limestone containing *Spirifer* was at one time exposed in the Baldow Glen, but is no longer visible. It seems to occur about the position of the Hollybush Limestone of the Hurlet area, which has recently been identified in this district, and also in Craigenglen and Glen Wynd, south Brae of Campsie, by Messrs. Macnair and Conacher.*

There is another limestone in the Duntocher district which has been correlated with the Blackbyre Limestone by the Survey, but by Messrs. Macnair and Conacher, perhaps with greater probability, with the Hollybush.† It can be seen above the bank of the stream, a quarter of a mile west of Lawmuir Farm, where about 6 ft. of shaly limestone is visible. There is also an excellent section of the seam at the entrance to an old quarry in the overlying sandstone, near the hospital at Hardgate. Other sections can be examined along the burn below Auchentoshan House, and further up stream by the old mill at Duntocher. R. G. C.

CARBONIFEROUS LIMESTONE SERIES.

[A general section of the Carboniferous Limestone Strata in the Glasgow district, north of the Clyde, will be found on Plate VIII., Section 1.]

General Structure.—The Carboniferous Limestone strata which occupy the northern part of the Glasgow area are arranged in gentle undulations, giving rise to a series of domes and shallow basins. These are in turn traversed by a succession of roughly parallel major faults with trends ranging from N.W.-S.E. to nearly E. and W. and with downthrows in most cases to the south.

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* Macnair and Conacher, *op. cit.*, p. 43.

† *Op. cit.*, p. 50.

The dominant structural feature in the western City and suburban area is the anticlinal fold whose axis runs N.E. from the Clyde at Partick to Maryhill Barracks and thence nearly due east to Possil Park. The fold pitches to the east, and the lowest beds brought up westward along the anticline lie some distance beneath the Gas Coal.

The eastern limb of this fold is broken and the outcrops shifted for half a mile to the westward by a fault running over Hamilton Hill to the Kelvin at East Park. This fault has a downthrow to south of 11 fms. at Ruchill; the displacement increases rapidly to the eastward, beyond this area.

The northern limb of the anticline is also truncated, a short distance N. of the Lanarkshire and Dumbarton Railway, by an east-and-west fault (the Garnkirk Fault) which near Possil Park has a downthrow to south of 75 fms., bringing strata on the horizon of the Index Limestone against beds below that of the Gas Coal. At Maryhill it turns to the north and appears to split, the northern branch extending N.W. to Bearsden, with a throw of 90 fms. near Garscube House. The southern branch follows a nearly parallel course, also increasing in throw from 20 fms. at Maryhill to upwards of 70 fms. at Cloberhill. The Cadder Fault, which crosses the Cadder ironstone and coal field in an E.S.E.-W.N.W. direction immediately south of Buchley, has at this point, where proved in the Main Ironstone workings, a downthrow of 50 fms. to south-west. The displacement, however, decreases rapidly eastwards and the fault appears to die out before reaching Bishopbriggs; its inclination to the horizontal in the Cadder workings is only 1 in 2, or 27°. The line of fracture continues N.W. by Dougalston Loch and probably meets the powerful east-and-west Queenzieburn Fault which crosses the district south of Milngavie and throws the Carboniferous Limestone strata on the south against the Calciferous Sandstones of Douglas Muir. Besides these major dislocations, the outcrops of the seams, especially in the western suburbs, are much disturbed by minor faults, proved in the workings of the Possil coals and ironstones.*

The Cadder and Blackhill mineral fields are traversed by an east-and-west dolerite dyke—the western extremity of the Lenzie-Torphichen dyke. The dolerite is seen at the surface in an old quarry a third of a mile W.S.W. from Cadder Church; west of that point it has been proved underground in the workings of the Main Ironstone and Gas Coal to extend at least as far as the river Kelvin. The average breadth of the dyke is 40–50 yds., but decreases westwards, and at Blackhill does not exceed 60 ft.

The intrusion appears to have but little effect on the contiguous metals. L. W. H.

LOWER LIMESTONE GROUP.

Milngavie and Bearsden.

The Hurlet Seam.—The Hurlet Limestone averages 3 to 4 ft. in thickness, is dark grey in colour, and largely composed of encrinital debris; it also contains specks of iron pyrites. The Limestone is separated from the underlying coal by a thickness, seldom more than a few inches, of alum shale; the abundance of this mineral is probably due to the interaction of the alumina of the shale with the pyrites which occurs throughout the seam. The Coal varies from 4 to 6 ft. in thickness, but is generally soft and of poor quality: it invariably contains nodules of iron pyrites, often 6 inches in length. Beneath the Coal, which rests sometimes on fireclay, sometimes directly on blaes, there are usually one or two entomostracan bands. In the Campsie district these form a solid limestone, but south of the Clyde, and on the north side of the river probably as far as Milngavie, occur as an oily entomostracan shale which may pass into lenticular bands of limestone.

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* For further details of structure, see "Geology of the Glasgow District" (*Mem. Geol. Surv.*), 1911, pp. 157, 158, 168.

In the Baljaffray Pit, south of Bearsden, where the limestone and coal have been worked within recent years, the section of the seam is as follows:—

	Ft.	In.
Blaes		
LIMESTONE	2½ to 3	0
Alum Shale	0	6
COAL, with balls of pyrites near base .	4	0
Fireclay		

The limestone is of good quality and yielded a "fat" lime much used for local building purposes. The coal, which was used to burn the lime on the spot, is poor, and always contains balls of pyrites, which had to be picked out. At one time this pyrites had some value in the manufacture of vitriol, but newer processes have supplanted it. This is also the case with the alum shale, which at one time supplied material for a considerable alum industry, more especially in the Campsie district.

It is probable that the economic value of this seam has been destroyed over a considerable area to the west of Glasgow by the intrusion of the dolerite sill, whose effect on the metals is well seen in the Arkleston cutting section, described on p. 48. There are, however, large areas where the Limestone and Coal should be found in their normal condition, although perhaps at too great a depth for profitable working at present. A promising area for trial lies between Bearsden and Milngavie, east of Mosshead, where the superficial deposits are thin. The strata, as seen in the stream sections, undulate at low angles, and the seam should not lie at a greater depth than 100 fms., except near the railway.

Limestones belonging to the *Hosie Group* have been met with in several bores to the north and N.W. of Bearsden. They are usually thin and of no economic importance. They are apparently nowhere exposed at the surface in this district. R. G. C.

LIMESTONE COAL GROUP.

West Glasgow and North-Western Suburbs.

The Middle Group of the Carboniferous Limestone Series, as developed in the western part of the Glasgow area, includes an upper sub-group of coals and blackband ironstones—the Possil Sub-group;

and a lower division—the Garscadden Sub-group—containing both clayband and blackband ironstones of economic value with one or more workable coal seams. The whole Group is generally characterised by thick sandstones at the top and dark blaes towards the bottom of the series. The average total thickness of the strata is estimated at 175 fms.

The general succession of the Group is shown in the following Table; the figures give the average thicknesses of strata and distance below the Index Limestone and are subject to considerable local variation; certain of the seams are only recognised in limited areas, but have their equivalents in other parts of the district.

General Section showing the Position of the Principal Horizons of the Limestone Coal Group in the Glasgow Area—North of the Clyde.

			Thickness. Fms.	Depth below Index. Fms.
		Index Limestone.		
Possil Sub-Group.		Strata with one or more thin coals	35	
		Davy Coal = Upper Possil Coal = Main Coal of Cadder		35
		Strata	0–4	
		Wee Coal of Garscube = Upper Possil Ironstone = Blackband of Blairdardie and Drumchapel = (?) Batchie Ironstone of Cadder		39
	Cadder Ironstones	Batchie Ironstone		
		Strata	3–4	
		Main Ironstone		43
		Strata	4–5	
		14-inch Ironstone		
		Strata		
		Main Possil Coal = (?) 24-inch Coal of Blackhill		54
		Strata	2–3	
		Lower Possil Ironstone		57
		Strata	5–6	
		Possil Shale Coal = (?) 30-inch Coal of Blackhill		63
		Strata	3	
		Jubilee Coal = Old Blackband of Jordanhill		66
		Strata	3–5	
		Knightswood Gas Coal = No. 2 Coal, Cadder		70
		Strata	14	
Garscadden Sub-Group.		Black Metals, including the California Clayband Ironstones	10–15	
		Upper Garscadden Blackband or Knightswood Brown Stane		97
		Strata	12	
		Lower Garscadden Blackband = Govan or Ibrox Blackband		110
		Strata	3–7	
		Garibaldi Clayband Ironstones		115
		Strata	10	
		Kilsyth Coking Coal		125
		Strata, including the Johnstone Shell-bed	35	
		Johnstone Clayband Ironstone		
		Strata	12	
		Top Hosie Limestone		172

L. W. H.

IRONSTONES.*

Garscadden Ironstones.

This sub-group was formerly one of the chief sources of ironstone in the West of Scotland. The two seams of blackband ironstone—the Upper Garscadden Blackband or Knightswood Brown Stane and the Lower Garscadden (Govan or Banton) Blackband—have been practically worked out, as is also the case with most of the clayband ironstones, though considerable areas of the *Johnstone Clayband* still remain. This important ironstone occurs about 12–14 fms. up in the dark blaes which overlie the Top Hosie Limestone and form the base of this sub-group. Throughout the district west of Glasgow it averages a foot in thickness, and thinner bands are often associated with it close to the main seam. Although somewhat thinner round Knightswood, the seam is on the whole very persistent and constant in character, and in this respect affords a great contrast to most of the other ironstones in this part of the area. The Johnstone Clayband has been chiefly wrought south of the Clyde (see pp. 40, 54), but was raised north of the river at Garscadden and at Knightswood—at the former under the name of "The Lower Clayband."

At Garscadden the section of the seam showed:—clayband, 6 to 9 in.; blaes, 2 to 2½ ft.; clayband, 7 to 12 in. At Knightswood No. 10 Pit, where very little appears to have been wrought, the section was:—

	Ft.	In.
Blaes		
TOPS	1	0
Blaes	2	10
CLAYBAND	0	9
Blaes	0	1
Rough stone	0	5

The sections shown in these workings and in bores in the same district are very similar to those met with in the Johnstone, Cardonald and Nitshill areas south of the Clyde, where these claybands have been most extensively worked. Bores at South Mains give the seam as:—clayband, 4 to 7 in.; blaes, 2 to 11 in.; limy clayband, 9 to 14 in.; others at Knightswood and Garscadden show:—clayband, 4 to 13 in.; blaes, 2 ft. 8 in. to 3 ft. 3 in.; clayband, 7 to 12 in.

Further to the east, at Balgray, it is recorded as a 16-in. limy clayband, overlying 5 in. of harder clayband, but appears to deteriorate in that direction, and is scarcely recognisable in the Springburn and Cadder fields.

Both this seam and the Househill Claybands of the Lower Limestone Group are well developed in the ground between Duntocher and Dougalston Loch, south of Milngavie. In the old Prince Albert Pit, Duntocher, the Johnstone Clayband was found in two 10-in. beds, separated by 2 ft. 8 in. of blaes. The ironstones in this part of the district are as yet untouched.

The Johnstone Shell-bed, 15–19 fms. higher in the sequence, which forms a reliable index-mark for the Clayband, is best known south of the Clyde (see p. 42), but has been recognised in bores at Knightswood and Balgray, and near Colston, Bishopbriggs.

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* A more complete account of these will be found in the Memoir on the "Iron Ores of Scotland" (*Mem. Geol. Surv.*), 1920.

The Garibaldi Clayband Ironstones lie at an average distance of 10 fms. above the Kilsyth Coking Coal position, and 3 to 5 fms. below the Lower Garscadden or Govan Blackband: they occur near the base of a thick mass of blaes, and form a readily recognisable horizon. South of the Clyde they are very thin, but become of workable value on the north side of the river in the district of Knightswood and Garscube, where the ironstone was raised, up to the year 1892, over a considerable area in the neighbourhood of Jordanhill, Skaterigg, Gartnavel, Cloberhill and Knightswood. The average section in these workings showed:—

Blaes, brushed	2 ft.
CLAYBAND	4 to 6 in.
Blaes	2½ ft. to 3½ ft.
CLAYBAND	6 to 8 in.

The ore in this area is stated to have been of excellent quality and the best clayband in the district.* An analysis of the "char" from Jordanhill gave:—

	Per cent.
Fe	38·92
Insoluble	20·70
MnO	0·52
P	0·66
S	0·30
SiO_2	14·80

Further to the north these ironstones were wrought to a small extent at Garscube on the south side of the Kelvin, west of Dawsholm Paper Works; a few small areas were also opened at Garscadden about the years 1870–80.

The sections of the seam at these two localities were as follows:—

GARSCUBE.	Ft.	In.	GARSCADDEN.	Ft.	In.
Blaes roof			Blaes roof		
TOP STONE	0	6	TOP STONE	0	4
Blaes	2	10	Blaes	up to 2	9
Limestone	0	4	BOTTOM STONE	0	3
BOTTOM STONE	0	7 to 12	Blaes	1	6
Blaes pavement			FREE COAL	0	6

At Garscube part of the lower rib was of poor quality, and the workings were soon abandoned.

Two old "ironstone" pits at Ruchill and Keppoch, Glasgow, are also supposed to have been sunk to this horizon.

A coal position, known locally as the *Garibaldi Coal,* usually occurs about 1½ fms. below the Garibaldi Claybands: round Jordanhill this becomes a blackband ironstone, known as the *Jordanhill New Blackband.* It was discovered in 1879 in proving a 16-ft. downthrow in No. 8 Pit, and was wrought over a very small area: the section was:—

	Ft.	In.
Fakes roof		
Blaes	1	6
IRONSTONE, streaked with Coal	0	4
BLACKBAND	0	6
Sandstone pavement		

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* M'Lennan, "Notes on Jordanhill Coalfield," *Trans. Geol. Soc. Glasgow*, vol. viii., 1887, p. 271.

The Lower Garscadden Blackband, 10 to 13 fms. below the Upper Blackband, occurs in the middle of the thick blaes near whose base lie the Garibaldi Claybands. It is the equivalent of the Govan or Ibrox Blackband south of the Clyde, and is represented in the Kilsyth district by the Banton, or Kilsyth No. 4 Blackband.

This Blackband was wrought up to the year 1884 at Garscadden, where the section of the seam was:—

	Ft.	In.
Blaes roof		
BLACKBAND	0	5
COAL	0	4
Blaes	2	2
Blaes pavement		

Local thicknesses of 11 to 13 in. have been met with in bores but this appears to be exceptional.

Elsewhere, north of the Clyde, at Jordanhill, Knightswood, Garscube, Maryhill, etc., it is represented by a thin 8 to 14-inch coal, with an ironstone rib of 2 or 3 in. above it.

The Upper Garscadden Blackband or *Knightswood Brown Stone* lies at the base of the series of dark blaes and ironstone ribs known as the Black Metals, and, like the Lower Blackband, is of local occurrence only. It was first met with at Garscadden,* and was raised over a considerable area at Jordanhill, Skaterigg, Knightswood, Garscube and Cloberhill up to the year 1896.

A typical section in these workings showed the following:—

	Ft.	In.
Blaes roof		
Blaes, brushed	2	6
COALY blaes	0	2 to 3
BLACKBAND	0	4 to 13
Blaes	0	0 to 6
Sandstone pavement		

The sandstone floor distinguishes this seam from the Lower Blackband, which rests on blaes.

The seam was also wrought for over twenty years at Garscadden, where the section was:—

	Ft.	In.
Blaes roof		
Blaes, brushed	2 to 3	0
BLACKBAND		8 to 11
Sandstone floor		

At Gartnavel it was worked to a small extent from No. 7 Pit, but here measured only 6½ in. and thinned out eastwards.

The California Claybands lie towards the base of the Black Metals. This series of dark blaes, which varies from 10 to 18 fms. in thickness, contains throughout numerous thin ribs and nodular layers of clayband ironstone: in the lower part these increase in number and thickness, and become locally of workable value. For the most part the ironstone ribs measure from 2 to 6 in., but occasionally reach a thickness of 9 to 14 in. The seams wrought in the Glasgow district under the name of the California Claybands occur 3 to 4 fms. above the Upper Garscadden Blackband.

They were worked for a considerable period about the middle of the last century in the neighbourhood of Gartnavel, and at a later date a small area was opened up at Garscube; where, however, the ironstones proved to be thin and poor in quality. These claybands have been proved in a number of bores in the ground further to the west and north-west, where an average section shows 13 in. of ironstone in 3½ to 4½ ft. of blaes, while locally the thickness of ironstone reaches 16 or even 21 in.

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* M'Lennan, *op. cit.*, p. 274.

There is no doubt as to the existence of a considerable reserve of clayband ironstone ore at this horizon.

The Possil Ironstones.

The Old Blackband of Jordanhill, which may be taken as the lowest ironstone seam in the Possil sub-group, was wrought for a period of thirty years in the Jordanhill-Skaterigg field, becoming finally exhausted about the year 1867. The ore was of excellent quality and yielded a high percentage of metallic iron. The average thickness of the seam as given by M'Lennan was 18 in. It lies 3 to 5 fms. above the Knightswood Gas Coal, and persists as a thin blackband into the western part of the Gartnavel field, where it is only 6½ in. thick. Hence it passes eastwards into a 12 to 15 in. coal, and to the north, on Knightswood and Garscube, is represented by the 2-ft. Jubilee Coal.

The Jordanhill Blackband has sometimes been correlated with the Lower Possil Ironstone, which, however, lies higher in the sequence, some 12 fms. above the Gas Coal and 2 to 3 fms. below the Possil Main Coal.

The Lower Possil Blackband was formerly raised from several pits in the northern suburbs of Glasgow, but these have been long abandoned, and as the ground is now built over there is little chance of any of the ore being still available. Sections of the seam from these workings are given below.

HAMILTONHILL.	In.
Blaes	
PARROT COAL . .	3
BLACKBAND IRONSTONE .	9
Parting, soft . .	2
COAL . . .	11
Sandstone and fakes	

SARACEN COLLIERY, POSSIL.	Ft.	In.
Blaes		
BLACKBAND . . .	0	5
Dirt	0	5
COAL	1	0
Freestone		

This horizon is only locally occupied by a blackband ironstone; elsewhere, as at Gartnavel, Skaterigg, Garscube, etc., it is represented by one or more thin coals.

Cloberhill Blackband.—A thin blackband ironstone lying 2 fms. above the Main Coal has been wrought to a small extent at Cloberhill, Knightswood, but the seam is very local in its occurrence.

SECTION AT CLOBERHILL.	In.
Blaes roof	
IRONSTONE	4
"Blacks"	4
IRONSTONE	2
COAL	3
Daugh	3
Fakes pavement	

Blackbands of Blairdardie and Drumchapel.—A 10-in. ironstone 16 fms. above the Knightswood Main Coal, was formerly raised at Blairdardie, and a blackband 19 fms. above the same coal, and no doubt on the same horizon, was worked to some extent at Drumchapel. Here the section was:—

	Ft.	In.
Blaes roof		
Coaly blaes	0	6
Blaes	1	6
Coaly blaes	0	10
COAL	0	4
IRONSTONE	0	6
COAL	0	2
Sandstone pavement		

Further to the east this seam appears to be represented by the Wee Coal of Garscube, Netherton and Knightswood, which lies about 16 fms. above the Knightswood Main Coal, and has very generally an ironstone rib in its roof. It may also be the equivalent of the Upper Possil Ironstone of the Possil fields.

L. W. H., M. M.

The Cadder Ironstones.—A small part of the Cadder ironstone field, one of the very few localities in which blackband ironstone is still being raised in Scotland, comes within the north-eastern limits of Area IV., and the *Main Ironstone*, 40–50 fms. below the Index Limestone, is now (1917) wrought at No. 17 Pit, Wilderness Plantation, by the Carron Company.

An average section of the Main Seam is as follows:—

CLAYBAND IRONSTONE . . .	2 to 4 in.
Dark blaes	9 to 16 „
PARROT COAL	3 „
BLACKBAND IRONSTONE . . .	5 to 10 „
ROUGH COAL . . .	9 to 20 „
Irony Parrot	2 to 7 „

Other blackband ironstones at one time worked in the Cadde field, are the *14-in. Ironstone*, lying at an average distance of 4 fms. below, and the *Batchie Ironstone*, 3 to 4 fms. above, the Main Ironstone

In the 14-in. seam the blackband varies from 6 to 13 in. in thickness and is associated with a thin parrot coal. The average section of the Batchie is:—parrot coal, 13 to 18 in.; blackband ironstone, 3 to 7 in.; coal, 3 to 7 in. The Batchie is possibly the equivalent of the Upper Possil Ironstone of some of the older workings in the Possil area, but the correlation of particular seams in the different fields is difficult and not always satisfactory, since these ironstones were probably laid down, individually, over very limited areas and often pass laterally, from the diminution of the ironstone portion of the seam, into coals. A fuller description of the ironstones of this and of the adjoining fields is given in the Memoir descriptive of Area V.*

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* "The Economic Geology of the Central Coalfield of Scotland, Area V." (*Mem. Geol. Surv.*), 1916, p. 9.

The Main Ironstone was also wrought over a considerable area on both sides of the Kelvin from the Blackhill Pits, Summerston, up to about the year 1907. L. W. H.

COALS.

The Kilsyth Coking Coal, the lowest workable seam in the Limestone Coal Group, has been recognised in most of the deep bores put down to this position in the district. It lies at an average depth of 120 fms. below the Index Limestone; this distance appears to decrease towards the east. Up to the present time (1917) the Kilsyth Coal has not been opened up within the City limits or north-eastern suburbs, the nearest point where it is raised being at the Auchengeich Pit, Chryston. There is little doubt, however, that a considerable field of this valuable coking coal exists at a reasonable depth in the area lying north and north-north-east of the City, on the upthrow side of the Comedie Fault. The Coal in the district around Bishopbriggs and Robroyston averages 18 to 24 in., and appears to increase in thickness towards the east, since at Auchengeich it measures from 22 in. to 3 ft. In the Knightswood and Drumchapel fields a coal with an average thickness of 17 in. and lying about 30 fms. above the Johnstone Clayband is regarded as the equivalent of the Kilsyth Coking Coal. It was wrought over a small area near No. 9 and 10 Pits, Knightswood, where the section was:—

	Ft.	In.
Blaes	3	0
Daugh	0	4
COAL	1	5
Fakes		

But very little is known as to the further development and nature of the seam.

In No. 3 bore Garscadden the seam was recorded as:—gas coal, 1 in.; free coal, 13 in., and it is of interest to note that south of the Clyde at Cardonald a coal in the position of the Kilsyth Coal was worked under the name of the "Gas Coal." In a bore at Balgray, Kelvinside, a 12-in. coal is recorded in the Kilsyth Coking Coal position.

The Possil Coals.

The lowest workable seam of this sub-group is the *Knightswood Gas Coal*, which was largely wrought in the neighbourhood of Glasgow at the time when cannel coals were in demand for the manufacture of gas. In the coalfields of Knightswood, Jordanhill, Cloberhill, Garscube, Blairdardie and Drumchapel, the average thickness of the seam was slightly under 2 ft.; the rib of gas coal, from which it derived its value, measuring from 4 to 10 in., but variable and apparently thinning away to the west, since at Blairdardie the seam was wrought as a 2 ft. 3 in. "free coal," and at Drumchapel as a "soft coal" of about 2 ft.

The following sections from the old workings show the variations in the nature of the seam:—

JORDANHILL.

	In.
COAL	4
Wild GAS COAL	3
GAS COAL	9

No. 2 PIT, CLOBERHILL.

	In.
Blaes	
COAL (free)	0 to 3½
GAS COAL (inferior)	0 to 5
„ „ (good)	0 to 10½
COAL	7 to 15

GARSCUBE FIELD

	In.
FREE COAL	4 to 5
Foul GAS COAL	4
GAS COAL	2 to 4
FREE COAL	9 to 15

No. 10 PIT, GARTNAVEL.

		In.
1 ft. 10 in.	COAL	4
	Sclit	3
	GAS COAL	4
	COAL	11

In the long abandoned Saracen Pits, Glasgow, the seam was 2 ft. thick with 5 in. of gas coal; at Eastpark, 20 to 24 in.; and at Hamiltonhill, 2 ft.

At the present time (1918) the Knightswood Gas is being raised, as a steam coal of good quality, by the Summerlee Iron Company from their pits at Blackhill, Summerston. The seam at Blackhill varies in thickness from 2 ft. 6 in. to 2 ft 9 in., with 4 to 10 in. of gas coal.

The Gas Coal is probably present in workable thickness in the unexploited area around Westerton, south of Bearsden; in two bores at Chapelton, on the N.E. side of the Bearsden Fault, it was recorded as measuring 2 ft. 2 in., with a 5-in. rib of "parrot" forming the top ply.

The Jubilee Coal, 3 to 5 fms. above the Gas Coal, is not present as a workable subject in the Cadder and East Possil fields, but was at one time wrought as a rough steam coal in the Garscadden and Garscube district. One section at Garscube reads:—

	Ft.	In.
Blaes, brushed	2	6
COAL	1	4
Stone	0	10
COAL	0	9

To the west of Partick it appears to pass into a blackband ironstone:—the Old Blackband of Jordanhill and Skaterigg. (See p. 83).

The Shale Coal of Possil, 7 fms. above the Gas and 7½ fms. below the Main, was a short time ago visible in the old quarries, now being filled up, on the east side of the road at Lambhill, where it was 2 ft. thick with a blaes and shale roof and sandstone pavement. The old crop workings at Lambhill are separated by an east-and-west fault with downthrow to south of 70 fms. from the pits at Hillend where the Upper Possil Blackband was formerly raised from a depth of 38 fms. A narrow "whin" dyke running N.E.-S.W. passes through this fault and has burnt the coals, to a slight degree, in the direction of Ashfield. The Shale Coal was also wrought during the last century at Eastfield, Eastpark, Maryhill and the Saracen Pits, Possil; at the last-named the section was:—

	Ft.	In.
Blaes roof		
Shale	2 to 3	0
Coal	2	3
Sandstone floor		

The seam probably takes its name from an inferior oil shale which usually overlies the coal and could recently be seen in an old quarry 200 yds. east of Over Possil, as well as in the Lambhill sections already referred to.

A coal lying 6 fms. below the Main and 8 fms. above the Gas was wrought about the years 1874–80 from the No. 9 and 12 Pits, Knightswood, under the name of the *Knightswood Stone Coal*: the section of the workings was as follows:—

	Ft.	In.
Blaes		
Shale	1	8
Tops (*i.e.* top coal)	1	3
Till	0	2
Bottoms (*i.e.* bottom coal)	1	3
Rock		

From its position it is probable that this seam represents the Shale Coal of the Possil fields. At Skaterigg and Gartnavel the same position is occupied by a 10-in. coal.

The *Thirty-inch Coal*, now being raised as a steam coal of good quality at the Blackhill Colliery, may also be correlated with the Possil Shale Coal. It lies 7 fms. above the Knightswood Gas, and occurs in two leaves—the bottom coal 17 to 20 in., the top coal 9 to 10 in. thick,—separated by a varying thickness of 4 in. to 5 ft. of blaes or bastard fireclay.

The Main Possil Coal, which lies at an average distance of 7 to 8 fms. above the Shale Coal, was wrought during the last century in most of the now abandoned pits of the Possil and Bishopbriggs coalfields. At Eastpark, Maryhill, the section was—wild parrot, 9 in.; wild gas coal with slate parting, 12 in.; free coal, 12 in. At Hamiltonhill the seam measured 18 to 24 in.; at Huntershill, Bishopbriggs, 2 ft. 6 in. with roof and pavement of faky sandstone.

The Main Coal of Knightswood and Garscube, which has been extensively wrought along the outcrop from Drumchapel to Gartnavel, is presumably on the same horizon as the Possil Main but is much thicker, giving 3 to 5 ft. of free coal and increasing westwards to nearly 6 ft. south-east of Blairdardie. Further to the north, around Drumchapel, sandstone partings appear in the coal, splitting it into two or more leaves.

The following sections from different workings illustrate the variation in the seam from east to west:—

Gartnavel No. 10 Pit.	Ft.	In.
Blaes		
Fireclay	1	2
Sclit	0	3
Coal	1	10

Knightswood.	Ft.	In.
Blaes		
Daugh	0	4
Shale	0	1
Splint Coal	1	0
Soft dirty Coal	0	1
Free Coal	1	0
Sandstone		

Blairdardie Pit. (*East of Canal.*)	Ft.	In.
Fakes and blaes		
Coal	2	4
Parting	0	2
Coal	1	4

Blairdardie.
(*West of Canal.*)

	Ft.	In.
Coal	4	2
Dirt	0	8
Coal	0	10

Drumchapel.

	Ft.	In.
Blaes		
Coal	2	2
Sandstone	1	8
Coal	1	0
Sandstone	1	3
Coal	1	0
Sandstone		

The seam now (1918) being wrought at the Blackhill Pit under the name of the *Twentyfour-inch Coal*, is probably the equivalent of the Main Possil. At Blackhill it lies 10½ fms. above the Gas Coal and has an average thickness of 2 ft. with a blaes roof and hard sandstone pavement: it supplies a good steam coal.

The Main Coal is present in the unworked area round Westerton already referred to, and an indication of the character of the seam is afforded by a bore near Garscadden Mains, which records the following section at the Main Coal position:—

	Ft.	In.
Coal	1	6
Sandstone	1	11
Blaes	2	6
Coal	1	2

The Wee Coal of Garscube, Knightswood and the north-western suburbs of Glasgow lies about 15 fms. above the Main Possil. It is a thin coal, sometimes with a parting of fireclay or sandstone, and has usually an ironstone rib in the roof: it is regarded as the equivalent of the Blackband of Blairdardie and Drumchapel (see p. 84).

The comparative sections given below indicate that it also occupies the same horizon as and passes eastwards into the Upper Possil Ironstone:—

Section of the Wee Coal at Skaterigg.

	Ft.	In.
Clayband Ironstone	0	4
Blaes	0	4
Blackband Ironstone	0	4
Coal (Little Coal)	1	8

Upper Possil Ironstone at Hamiltonhill.

	Ft.	In.
Clayband	0	3½
Blaes	0	9½
Parrot	0	2½
Blackband	0	5
Coal	1	6

The same distance of 3½ fms. separates the Wee Coal from the Davy Coal and the Upper Possil Ironstone from the Upper Possil Coal.

The Davy Coal of the Garscube-Knightswood district follows 3 to 4 fms. above the Wee; it is a soft coal with an average thickness of 1 ft. 10 in. to 2 ft. Westwards it appears to thin out, being represented at Drumchapel by 13 in. of foul coal or coaly blaes; eastwards its position is occupied by the Upper Possil Coal and Main Coal of Cadder.

The Upper Possil occurs usually in two leaves, the upper averaging 6 in. in thickness, the lower 18 to 30 in., with a 2-6 in. parting. It was raised in past years at Gilslochhill, Hamiltonhill and elsewhere in Glasgow. In some parts of the field, as in the old workings of Possil Park and Hillhead, it appears to have formed one seam together with the Upper Possil Ironstone, though usually separated from it by 3 to 4 fms. of strata. A thin but workable coal known as the *Bank Coal,* occurs about 7 fms. above the Davy on both sides of the Kelvin above Garscube Bridge; it thins out rapidly to the west and south and is evidently of purely local occurrence.

The highest seam now being worked at the Blackhill Pits is regarded as the equivalent of the Upper Possil. It lies a short distance above the "Batchie" or Upper Blackhill Blackband, and is a steam coal of good quality 27 in. in thickness.

L. W. H., M. M.

The Cadder Coals.—In the Cadder field, of which a small part falls within Area IV, four workable coal seams known as the *Cadder Coals,* lie beneath the Upper Possil Coal at average distances respectively below the Index Limestone of 65, 70, 73 and 75 fms. The lowest of these, No. 2 Coal, usually contains a rib of gas coal, and can be correlated with some certainty with the Knightswood Gas Coal. No. 3 is believed to be on the horizon of the Possil Shale Coal, while the highest seam, No. 5 Coal, is locally regarded as the equivalent of the Bannockburn or Cloven Coal, which in the Kilsyth and Denny districts lies 60 to 70 fms. below the Index Limestone.

Nos. 4 and 5 of this group are now (1918) being raised from Cadder Wilderness Pit No. 17. No. 4 is a steam coal of fair quality, 2 ft. 1 in. in thickness; No. 5 is also a fairly good steam coal; the section of the seam here is as follows:—

	Ft.	In.
COAL	0	8
Blaes	0	4
COAL	1	6

The workings in these coals extend south from the pit beneath the Canal towards the rise, the dip being to N.N.E.

Glasgow Sections.—In past years the Possil Seams were extensively wrought throughout the area now occupied by the streets of Kelvinside, Hillhead and Kelvingrove, and the outcrops of most of the coals were at one time visible along the gorge of the Kelvin between Belmont Street Bridge and Kirklee; the artificial dressing of the banks has now, however, obscured the sections.

A good section was also recently exposed in the freestone quarries at Eastpark, but these are now filled up.

The sequence here was as follows:—

	Ft.	In.
Dark coaly blaes		
COAL, JUBILEE	2	0
Blaes, with sandstone ribs . . .	4 ft. to 6	0
Hard sandstone, eroded surface . .	5	0
Faky sandstone	0	9
Blaes	6	0
COAL, GAS	2	0
Fireclay	0	4
Sandstone	14	0
Blaes		

The 2-ft. coal with blaes roof and thick sandstone below, exposed at the side of the road leading down from Gairbraid Street to the Maryhill Goods Station, is probably the continuation of the outcrop of the Gas Coal from the Eastpark Quarry. A fault with downthrow to S.W. of about 18 fms. crosses the railway 100 yds. east of the Gairbraid Street Bridge; the section seen in the cutting on the upthrow side of this fault repeats the beds below the Gas Coal, including a thick series of dark blaes with ribs and nodular layers of clayband ironstone and a 6 to 8-in. coal, representing the Black Metals. During the construction of the tunnel beneath Tamshill, east of the canal, a section was laid bare showing 5 coal seams 10 to 24 in. thick, dipping N.E. at an average angle of about 14°, and associated with alternations of thick sandstones and blaes. The stratigraphical position of these metals lies between the Gas Coal and the Upper Possil, and the coal crops presumably include most of the seams of the Possil Group.

Undeveloped Areas.—A considerable area of the Possil Coals, as yet apparently untouched, extends northward from the river Kelvin between Garscube and Killermont to the Allander Water north of Boclair. Bores put down in the 'sixties of the last century on the lands of Millichen and Boclair proved coal seams of workable thickness at at least two horizons; a bore 450 yds. N.E. of Kessington records a coal 1 ft. 8 in. at 83 fms., and a " parrot and rough coal " 3 ft. 7 in. at 93½ fms., 47 fms. below the Index Limestone; another on the north side of the Kelvin, 150 ft. east of the boundary-ditch of the Killermont policies, met with a 3 ft. 4 in. "parrot" coal at 139 fms. and one of 21 in. at 146 fms. It should, however, be pointed out that the drift-buried pre-glacial channel of the Kelvin crosses this area between Boclair and Kessington, the depth of superficial deposits proved in the bore at Millichen Wood amounting to as much as 339 ft. In addition to the great thickness of loose material present in this channel, and to be taken account of in boring or sinking shafts, the position of the seams near their outcrop will be considerably affected as they cross this deep and steep-sided buried valley (see also p. 95).

UPPER LIMESTONE GROUP.

The rocks of this group form on the whole an arenaceous series, with two well-defined sandstone horizons both of considerable economic value, and several bands of limestone; most of the latter are remarkably persistent and constant in character, though rarely more than a few feet in thickness. The principal horizons are, in ascending order, the Index Limestone; the Bishopbriggs Sandstone; the Lyoncross Limestone and Coal; the Orchard Limestone and Blaes, and the Calmy or Arden Limestone with the underlying Hirst or Shirva Coals.

The Upper Limestones are rarely exposed at the surface in that part of Area IV. lying north of the Clyde, and the position of the outcrops of the Index and Calmy seams shown on the maps of the ground south of the Kelvin valley are based on mining evidence, the principal horizons of the group having been identified in most of the shafts and bores put down in the Cadder, Possil and Blackhill coal and ironstone fields.

The Index Limestone, which forms the base of the series, is usually a hard, grey, ochreous-weathering limestone, sometimes dolomitic, with an average thickness of 4 to 5 ft., and is invariably overlain by a considerable thickness of dark blaes with nodules of clayband ironstone. Two surface exposures have been observed in the north-western suburbs of the City; one of these occurs in the south bank of the Kelvin, ¼ mile south of Garscube Bridge, where the limestone is turned up against a large east-and-west fault which follows the river; the other is met with in the railway cutting on the east side of the aqueduct at Dawsholm Gasworks. It is also well seen, less than a mile beyond the eastern margin of the present area, in the railway cutting at the High Possil Road Bridge, south of Bishopbriggs. Here the limestone is distinctly dolomitic: the seam is 4 ft. in thickness, and is underlain by a thin coal.*

Blocks of a similar limestone are seen on the site of an old shaft by the side of the railway, 400 yds. N.E. of Possilpark Station, where the seam is presumed to lie near the surface.

In the Cadder, Blackhill and Millichen fields the Index was found to average from 4 to 5 ft. in thickness, reaching 5 ft. 8 in. in Cadder No. 17 Pit.

The blaes above the Index is followed by the *Bishopbriggs Sandstone*, a persistent horizon, which has yielded one of the most valuable building-stones in the Glasgow district, and was mined and quarried on a large scale at Bishopbriggs up to the year 1908 (see "Economic Geology of Central Coalfield, Area V.," *Mem. Geol. Surv.*, 1916, p. 15).

The base of this sandstone is often coarse and pebbly; this pebbly character is well marked within the City at Rockvilla and Cowlairs, where the sandstone outcrop gives rise to a conspicuous feature.

In the series of sandstones between the Index and Lyoncross Limestones exposed along the Kelvin in the neighbourhood of Dawsholm, the upper part of the sequence is pebbly, while the lower beds are fine grained. Between the two is a thin coal, which can be followed in a line of old "ingaun-e'es" at the base of the grit escarpment east of the river.

The *Cement-stone*, a thin impure limestone, generally in two bands, which rests upon the Bishopbriggs Sandstone in the Huntershill and Coltspark freestone quarries, seems to be fairly persistent in the ground between Bishopbriggs and the Kelvin valley, and has been recorded in most of the bores put down in that district. In the shaft of Cadder No. 17 Pit it occurs in two bands 4½ and 20 in. thick, 40 fms. from surface. It appears to have little or no economic value.

The *Lyoncross* and *Orchard Limestone* horizons are nowhere visible in natural section, but are represented in most of the bore journale from this district by "calmy" limestones 20 to 30 fms. apart, and varying in thickness from 7 in. to 1 ft. for the lower, and from 1 to 3 ft. for the higher seam. The strata between the Bishopbriggs Sandstone and the Lyoncross position contain two or three thin coals, which further to the east are locally of workable thickness, and have been wrought between Kirkintilloch and Kilsyth under the name of the Chapel Green Coals.

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* "Geology of the Glasgow District" (*Mem. Geol. Surv.*), 1911, p. 48.

The *Hirst Coals* can only be present over a small part of this district on either side of the Kelvin between East Millichen and Cadder. They were worked many years ago at Robroyston and Hogganfield, further to the east, but we have no record of their having ever been raised within this part of the Glasgow area. The Upper Hirst is recorded in several bores in the neighbourhood of Buchley and Buchleyford, where it measures 2 ft. 6 in. to 2 ft. 9 in. in thickness, and lies 2 to 2½ fms. below the Calmy Limestone. In a bore near Easter Lumloch it reached 3 ft. 6 in., and increases considerably in thickness further to the east, beyond the present area.

A coal corresponding in position to the Lower Hirst but less than 2 ft. in thickness, was also met with in two of the bores near Cadder, at a distance of 2 to 5 fms. below the Upper Seam.

The *Calmy*, also locally known as the *Robroyston* or *Garnkirk Limestone*, is similarly confined to a very small area and is nowhere seen at the surface, but has been recorded in all the bores that have passed through the position. It occurs almost invariably in two bands of unequal thickness, separated by 1 to 2 ft. of blaes, the total measurement of the seam varying from 4 to 8 or 9 ft. The limestone was at one time wrought at the Robroyston quarries, a short distance beyond the eastern limits of this district, and the following analysis of a sample from this locality was contributed by the late Mr. J. S. Grant Wilson to the "Geology of the Glasgow District": *—

CALMY LIMESTONE.

Spoil heap, Robroyston old quarry, 1¼ miles west of north of Hogganfield Loch, Lanarkshire. A light grey limestone, very compact and fine grained, with a cubical and splintery fracture.

SiO_2	9·03
Al_2O_3	6·45
Fe_2O_3	2·4
MnO	·07
CaO	36·46
MgO	7·39
Alkalies	Undetd.
CO_2	38·22
H_2O above 100° C.	·01
	100·03
$CaCO_3$	65·11
$MgCO_3$	15·52

Cementation Index = ·69.

The CO_2 will satisfy the whole of the lime and magnesia less ·32 per cent. The rest of the constituents are probably more or less in combination, leaving little free silica.

The strata above the Calmy Limestone in the Cadder area are, for the most part, deeply buried beneath the superficial deposits which fill up the pre-glacial Kelvin valley (see p. 95).

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* "Geology of the Glasgow District" (*Mem. Geol. Surv.*), 1911, p. 225.

In a bore on the Balmore Haughs, put down in the deepest part of one of the minor basins, a limestone was met with, 54 fms. above the Calmy position, which is considered to represent the *Castlecary Limestone.* It lies at a depth of 64 fms.—40 fms. of this distance being occupied by surface deposits,—and is followed above by 20 fms of sandstones and fireclays, referable to the Millstone Grit Series.

MILLSTONE GRIT.

A small outlier of Millstone Grit is concealed beneath the thick superficial deposits of the Balmore Haughs in the Kelvin valley, where a considerable thickness of red sandstones and fireclays above the Castlecary Limestone has been proved in deep bores put down to the underlying Limestone Coals. A limited area of Millstone Grit strata is also probably present on the downthrow side of the Cadder Fault, between Buchley and Summerston.

Rocks of the same Series underlie the Coal Measures on the south side of the Clyde, and, as indicated on the map, probably come to the surface beneath the alluvial deposits of the river on the west side of Eglinton Street. L. W. H.

CHAPTER VI.

SUPERFICIAL DEPOSITS.

BOULDER CLAY.

BEYOND the area occupied by the thick deposits that fill up the pre-glacial valley of the Clyde, described in the sequel, p. 95, the rock is for the most part concealed by boulder-clay, which is in turn overlain by the sand and brick-clay deposits of the 100-ft. terrace. Through this covering the boulder-clay protrudes—particularly on the south side of the river—in mounds or ridges which are often elongated in a definite direction, corresponding to the movement of the ice by which they were laid down. Further to the south the boulder-clay forms almost the only surface covering, but is not in general more than 30 ft. in thickness, and has not, as far as is known, been used for any special purpose. North of the Clyde the boulder-clay reaches a greater depth, and at Hamiltonhill, where it is quarried to provide puddling material for the canal, the clay is at least 100 ft. in thickness. The deep bores put down through the deposits that fill the pre-glacial valley of the Kelvin, already referred to, passed through successive layers of red, brown and blue boulder-clay, separated by beds of sand and gravel.

The boulder-clay has occasionally been used, either alone or mixed with blaes from the waste-heaps, for the manufacture of composition bricks. The smaller stones are ground up with the clay, the larger boulders and limestone fragments being picked out.

SANDS, GRAVELS AND BRICK-CLAYS OF 100-FT. TERRACE.

The sands and gravels of this formation are of little economic importance, but the brick-clays are fairly wide spread, and have in one or two cases been used in the manufacture of bricks and tiles. A deposit of this nature is at present being worked at the Seedhill Quarry to the east of Paisley. Here from 3 to 5 ft. of sand overlie from 20 to 30 ft. of fairly pure brick-clay, which contains arctic marine shells,* but does not show very marked lamination. The latter rests on a more sandy clay which is water-bearing, and this in turn on further sand and gravel.

The clay is mixed with the sand at the top of the quarry, and a certain amount of ash is added for the production of wire-cut bricks. Agricultural drainage pipes are also made; for this purpose the clay is used without admixture.

Brick-clay of probably the same geological origin was formerly worked near Ibrox, and on both sides of the Glasgow and Paisley line near Craigton. That to the north of the railway is said to have been 20 ft. deep, and not very pure in character, being probably somewhat sandy. There is undoubtedly much of the material still left, both near Seedhill and to the west of Craigton, as well as in areas in this district where it has not yet been touched.

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* "Geology of the Glasgow District" (*Mem. Geol. Surv.*), 1911, p. 191.

Three small patches of brick-clay, coloured on the geological maps as alluvium, occur near the 200-ft. contour-line in the neighbourhood of Giffnock, and are evidently different in origin from the brick-clays of the post-glacial terraces. Two of these fields were formerly worked for tiles.

Some of the lower brick-clay in this district, as for instance that near Govan, also occurs in areas coloured on the geological maps as river or stream alluvium. The latter is, in these cases, merely a surface covering. Shells, where present, are a source of weakness in burning. They decrease in number, as a general rule, towards the east.

E. M. A.

BURIED CHANNELS.

The deeply-buried pre-glacial valley known as the Kelvin or Bearsden Channel crosses the north-eastern part of this area between Balmore and Clydebank, with an average breadth, as far west as Drumry, of slightly less than a mile.

The evidence supplied by a number of bores put down along the course of this channel shows that the sides are steep and that between Balmore and a point three quarters of a mile north of Clydebank, the depth of the infilling deposits of sand, gravel and clay along the centre of the channel ranges from 200 to upwards of 300 ft., the maximum depths recorded being 320 ft. at Buchleyford and 339 ft., 800 yds. north of Kessington.

This abnormal thickness of cover has to be taken into account in sinking bores and shafts and also in estimating the position of the seams: the effect of the deep buried valley on the outcrop is well illustrated on the geological maps in the case of the Hurlet Coal between Duntocher and Kilbowie.

A second buried valley, less than half the depth of the Kelvin channel, extends from Renfrew south-westwards beyond Paisley. It occupies much the same ground as the present valley of the Black Cart, but the deepest part of the old channel lies considerably to the south of the course of that stream.

The third buried valley coincides with the present course of the Clyde as far east as Cambuslang; it is the shallowest of the three, and that part of the channel in which the infilling deposits reach a depth of 100 ft. is very narrow and does not extend above Govan. At the point where the Clyde enters Area IV. just above Glasgow Bridge, rock-head in the bed of the river lies 95–97 ft. below ordnance datum level. Between Queen's Dock and the mouth of the Kelvin, the Clyde now runs close to the steep northern bank of its pre-glacial channel. The Kelvin flows over rock at Partick Central Station, while in the north-west part of the Timber Depôt close by the rock is 60 to 70 ft. below the surface.*

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* A detailed description of these buried channels, with a plan showing their extent and the depth below ordnance datum level of rock-head at various points, will be found in the "Geology of the Glasgow District" (*Mem. Geol. Surv.*), 1911, p. 174.

A depth of more than 100 ft. of sand, silt and "mud," resting in places on a thinner substratum of boulder-clay, has been met with in bores at Govan and further west at Hillington Wood. To the north of the latter locality the level of the rock-head, beneath the superficial deposits, rises over an irregular tract stretching eastwards from Renfrew to beyond Shiels. To this ridge has been given the name of the Renfrew Bank.

Several pits have been sunk through these deposits in the area south of the Clyde, but the operation of piercing the loose sand and silt must necessarily be attended with some difficulty.

L. W. H., E. M. A.

CHAPTER VII.

BUILDING STONE.

Limestone Coal Group.—Sandstone was formerly worked on a horizon just above the Titwood Gas Coal in one or two quarries at Craigton. At least 20 ft. of massive gritty sandstone were here exposed, but the material is too coarse to have been satisfactory for building.

At the old Nitshill Quarry, near the village of that name, two posts of sandstone were quarried. The lower of these was 17 ft. in thickness, and of good quality; the upper was a poorer stone, and separated from the lower by a certain thickness of strata. The lower post was consequently worked to some extent by mining. Its position lay between the Stone Coal and the Two-feet or Satturland Coal.*

Upper Limestone Group.—In the district near Barrhead, where the Barrhead Grit has its typical development, there are many deserted quarries on this horizon, but none that was worked on any large scale, the material being too coarse for a good building-stone.

The largest source of building-stone within the Glasgow district was for many years the well-known Giffnock Quarries. Near Giffnock almost the entire thickness of strata between the Lyoncross and Lower Orchard Limestones consists of sandstone (see Plate VII., Fig. 1). Only the lowest 60 ft. of this, however, has been worked to any extent, and the term "Giffnock freestone" is confined to the bottom layer of "Liver rock," 16 to 30 ft. in thickness. The quarries follow a line of outcrop in a west-north-westerly direction for about a mile, the beds being inclined at a very gentle angle to the south. In the Braidbar and New Braidbar Quarries the section (now partly obscured) consisted of 30 ft. of "Moor rock" resting on 30 ft. of Liver rock. The former is a somewhat porous sandstone, of less value than the underlying stratum, for which the quarries have been mainly opened. A "liver rock," as the name implies, is one in which no bedding is apparent, and which can be worked with equal ease in all directions.

These Braidbar quarries are remarkable for the extent to which the Liver rock has been mined, in order to avoid removing the cover of inferior sandstone, etc. The two quarries lie about 1000 ft. apart, separated by a low hill which has been completely undermined by galleries, and mining has also been carried on to the south of the two quarries. Broad stoops or pillars are left for support between the galleries, which are about 30 ft. in height.

In the Giffnock and other quarries further to the west, the section is similar to that already described, but the Liver rock is thinner, and the overlying post is termed "Grey rock," being different in certain respects from the Moor rock of the Braidbar quarries. The sandstone appears again between Bogton House and Hillhead, brought up by a fault. Several quarries have been opened along this outcrop, but the character of the stone is markedly inferior, the valuable Liver rock of the southern quarries being absent. The quarrymen state that the latter has a very limited extension, thinning out also in the underground workings to the south of the Braidbar quarries.

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* "New Statistical Account of Scotland," vol. vii., Renfrewshire, 1845, p. 36.

The principal market for the stone was naturally in Glasgow, and a very large number of buildings in the City consist of material from these quarries, more especially south of the river. The Scottish Wholesale Co-operative Society's Building in Morrison Street, the Head Office of the Glasgow Savings Bank in Ingram Street, the Glasgow Academy, the part of the Central Railway Station which faces Union Street, the east side of the Post Office in George Square, and a part of Glasgow University Buildings, may be cited as examples of its use. A certain trade was also done with Belfast, and some of the finer Liver rock has been exported to America and South Africa for building and monumental purposes. The quarries are at present (1918) all disused.

The following analyses of (I.) the Liver rock, and (II.) of "Grey rock above the Liver rock,"* from New Braidbar Quarry, were made by the late Dr. Wm. Wallace, and have been communicated by Messrs. Baird and Stevenson:—

	I.	II.
SiO_2	81·86	94·22
Al_2O_3	1·21	0·44
Oxide of Iron	2·59	1·83
$CaCO_3$	8·94	0·19
$MgCO_3$	4·76	0·19
Combined H_2O	0·48	1·30
H_2O at 212° F.	0·04	0·80
	99·88	98·97
Sp. Gr.	2·291	2·152
Absorption of water per cent.	4·1	6·2

Microscopical examination of the Liver rock shows that, as is almost invariably the case with sandstones, the quartz grains have grown so as to "tally," to a certain extent, along their margins. The rock has therefore a quartzose cement, but there is also present, filling up the gaps, some kaolin and limonite, and a considerable amount of carbonate. The latter is partly calcium, but also in part magnesium, and probably ferrous carbonate. The porosity of the Grey or Moor rock, as shown by the absorption of water, has an adverse effect on its weathering qualities. The Liver rock is somewhat better in this respect, as the pores are partly filled with carbonate. But carbonate is not the most satisfactory form of cement, as it is liable to be affected by the acid gases in a city atmosphere. A fuller discussion of this question is contained in the "Geology of the Glasgow District."†

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* Probably a part of the Moor rock.

† *Mem. Geol. Surv.*, 1911, p. 246.

Flagstones were also quarried in one part of the Giffnock quarries, but their presence is extremely local. The old quarry lay on the south side of the railway line, a short distance to the east of the present Giffnock Colliery. The series was never more than 20 ft. in thickness, and the quality was rather inferior. The flags were perforated by innumerable annelid burrows, and as the upper limit is formed in places by a strong line of local unconformity, the thickness is very irregular.† The horizon is probably above the Moor Rock and they may be older than the Moor Rock Coal, but there is nothing which certainly corresponds to the flagstones in any other part of the line of quarries. E. M. A.

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† See Macnair, "On the Physical Geology and Palæontology of the Giffnock Sandstones," *Trans. Geol. Soc. Glasgow*, vol. xi. (Part 2), 1900, p. 199.

APPENDIX.

GLOSSARY OF SCOTTISH MINING TERMS USED IN THIS MEMOIR.

Bastard.—Impure, *e.g.* bastard fireclay, impure fireclay.

Blacks.—Coaly blaes.

Blaes.—Mudstone, or shale in the geological sense, not containing much bituminous matter.

Blind Bore.—A bore put down from an underground working.

Blind Coal.—Coal which has been partly carbonised, and in general rendered useless, by its proximity to an igneous intrusion.

Blind Pit.—A shaft sunk from an underground working.

Brush.—To remove strata above or below a worked seam in making the roads.

Calmy Limestone.—Argillaceous limestone.

Daugh.—Soft, often coaly fireclay, where found above, below, or as a parting in a coal seam.

Dogger, Doggar, Doggart, or Dugger.—An irregularly shaped nodule or concretion, or a layer containing such nodules; sometimes used for inferior ironstone.

Fakes.—Thin-bedded argillaceous sandstone or sandy mudstone; passing through *faky sandstone* into sandstone, and through *faky blaes* into blaes.

Float.—A sill or sheet of igneous rock, either horizontal or inclined more or less in accordance with the bedding.

Grey Maggie.—Coal which has been converted into coke through the proximity of an igneous intrusion.

Holing.—The excavation of a thin layer of soft material beneath, above, or in the centre of a coal seam, as a preliminary to working it; or the layer so excavated.

Ingoing Eye or Ingaun E'e.—The mouth of a drift or mine from the surface.

Kingle.—Very hard sandstone, often cemented by carbonates.

Mine.—A drift either from the surface (Ingoing Eye or Day Level) or from underground workings (Cross-cut, Stone Mine); not a pit.

Mussels.—Fossil bivalve remains, usually of species of *Carbonicola*, but the term is of general application, and is applied to marine as well as to freshwater forms.

Musselband.—An ironstone or blaes crowded with "mussels."

Opencast.—A daylight working.

Parrot Coal.—A term for gas coal, often, but not always, restricted to such as is of inferior quality. The name has probably been derived from the crackling noise made by this type of coal in burning.

Pavement.—The layer immediately underlying a coal or other workable seam.

Plies.—Rapid alternations of strata of different character.

Rock.—Sandstone, except in the phrase "Limestone Rock."

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Roof.—The layer immediately overlying a coal or other workable seam.

Sclit.—Coaly blaes or slaty coal.

Shale.—In Scottish mining parlance used only for bituminous or oil shale.

Splint Coal.—Hard coal with a dull lustre, which does not cake or break up in a furnace.

Stone Mine.—See *Mine.*

Till.—Clay, blaes, or mudstone.

Tops.—The uppermost part of a seam of coal or ironstone.

Whin or Whinstone.—A term largely applied to hard igneous rock, though used also for other hard material.

Wild Parrot.—Inferior gas coal.

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	6 S.E.	4	3	4	3	1	6
	7 N.W.	4	3	3	9	1	6
	7 N.E.	4	3	4	3	1	6
	7 S.W.	3	9	3	9	1	6
	7 S.E.	4	3	3	9	1	6
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	6 N.E.	3	9	3	9	1	6
	6 S.W.	3	9	3	9	1	6
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	3 S.W.	3 9	3 9	1 6
	3 S.E.	4 3	4 3	1 6
	4 N.W.	3 9	3 9	1 6
	4 N.E.	2 3	2 3	1 6
	4 S.W.	4 3	4 3	1 6
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	7 N.E.	4 3	4 6	1 6
	7 S.E.	4 3	4 3	1 6
	8 N.W.	4 3	4 3	1 6
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	11 S.W.	3 9	3 0	1 6
	12 S.E.	3 9	4 3	1 6
	13 N.W.	5 0	5 0	1 6
	13 N.E.	4 3	4 3	1 6
	13 S.W.	4 3	4 3	1 6
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